Artificial Intelligence and Machine Learning Capabilities and Application Programming Interfaces at Amazon, Google, and Microsoft

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ABSTRACT

With the continuous development of artificial intelligence (AI) and machine learning (ML), cloud-based AI and ML have been hot in recent years. The trend is that cloud-based services and products have become a strategic weapon for giant tech companies. However, each major manufacturer's competitive strategy and focus are different, leading to fierce competition under the share and pattern of change.

This thesis starts with the overall development of AI and ML and introduces the history and status of cloud-based AI and ML development in technology companies. Then, by introducing official websites and open API interfaces and their documentation, I analyze the internal applications and external ecosystem of Amazon, Microsoft, and Google and compare the three companies' AI and ML platform development strategies. Finally, I predict the development direction of AI and ML platforms, including future business models and outbreak trends, and analyze these three companies' corresponding platform development strategies.

Thesis Supervisor: Michael A Cusumano
Title: Deputy Dean & Sloan Management Review Distinguished Professor of Management

Acknowledgments

Firstly, I would like to thank my supervisor, Michael A Cusumano, who has respected my ideas from the beginning of the topic selection to the final submission and has given me very professional feedback and the warmest responses every time. My supervisor is also the professor of my Platform Strategy and Entrepreneurship course, which, combined with my thesis, gave me a comprehensive knowledge system of platform strategy and a practical implementation plan, which is very beneficial to my study and work in the future. My supervisor showed me the spirit of a role model, and I will learn from my mentor for a long time.

Secondly, I would like to thank Tsinghua University and the Massachusetts Institute of Technology. During my two years in the joint training program, the two top institutions have broadened my horizons, enhanced my vision, and allowed me to meet excellent students. It also gave me a deeper understanding of business and a more specific life plan and career goals. This period will be an asset in the long run.

Finally, I would like to thank my parents. Since I was a child, my parents have always given me the freedom to follow my dreams. Their support has allowed me to continue my education after working for a few years and experience campus life to the fullest without any burden. Their support has always been a great motivation for me on my way.

Now that two years of study are ending, I would like to conclude my study period with this essay. I hope that after graduation, I will be able to apply what I have learned in school to create value and bring my energy to bear on society.

1. Introduction

With the outbreak of the epidemic, the degree of uncertainty has increased, with the world facing a massive crisis in public health, economy, and livelihood. Amidst the great uncertainty, the advancement of high technology has become one of the key drivers of certainty in the world's economic development. AI has generated tremendous value in various fields with the rise of deep learning, which has greatly improved productivity. However, AI is still early on the commercial curve and is still a long way from being fully commercialized on a large scale. Regarding cloud computing, the epidemic's impact has led to significant growth in demand for everything from online entertainment to online offices, driving up demand for cloud use in the pan-Internet industry. More industries and traditional enterprises are accelerating their cloud transformation, and offline cloud project construction is picking up speed day by day, driving the overall cloud market size to another record high.

Amazon, Microsoft, and Google have been deeply involved in cloud-based AI and ML for many years and have built different moats based on their respective company strengths. They are all hybrid platforms that combine innovation and transaction platforms. However, AI and ML are innovation platforms that generate more value by enhancing company products and connecting users to 3rd-party "complements". Providing API modules is the common service to connect users, and different opening APIs can represent different development strategies. With the cloud computing market gradually entering maturity, the competition is becoming increasingly fierce,

and the problems and room for improvement of each platform are exposed, making the development of platform strategies increasingly important.

In this thesis, we compile the applications and ecologies of Amazon Web Services (AWS), Microsoft Azure (Azure), and Google Cloud Platform (GCP) based on experiences and present strategic analyses for the cloud part as well as for the overall company strategies. The first chapter provides an overall introduction to the content of the thesis. The second chapter provides an overview of the historical development of AI and ML. The third chapter provides a comparative analysis based on the official website documentation and API modules of AWS, Azure, and GCP AI and ML platforms and analyzes the internal applications and external ecosystem of AI and ML at the corporate level. The fourth chapter analyzes the expected future trends of AI and ML platforms with the corresponding competitive strategies of the three companies. The final chapter summarizes the whole thesis.

2. Overview of Cloud-Based AI and ML Development

As shown in Exhibit 2.1 [1], revolutionary technologies' development and iteration cycles are becoming shorter, and the social benefits are becoming more apparent. As human society moves from digitalization to intelligence, AI and cloud computing are two significant areas that can significantly reduce costs and increase efficiency as productivity tools.

Exhibit 2.1: Adoption of Technology in the US (1900 to Present)
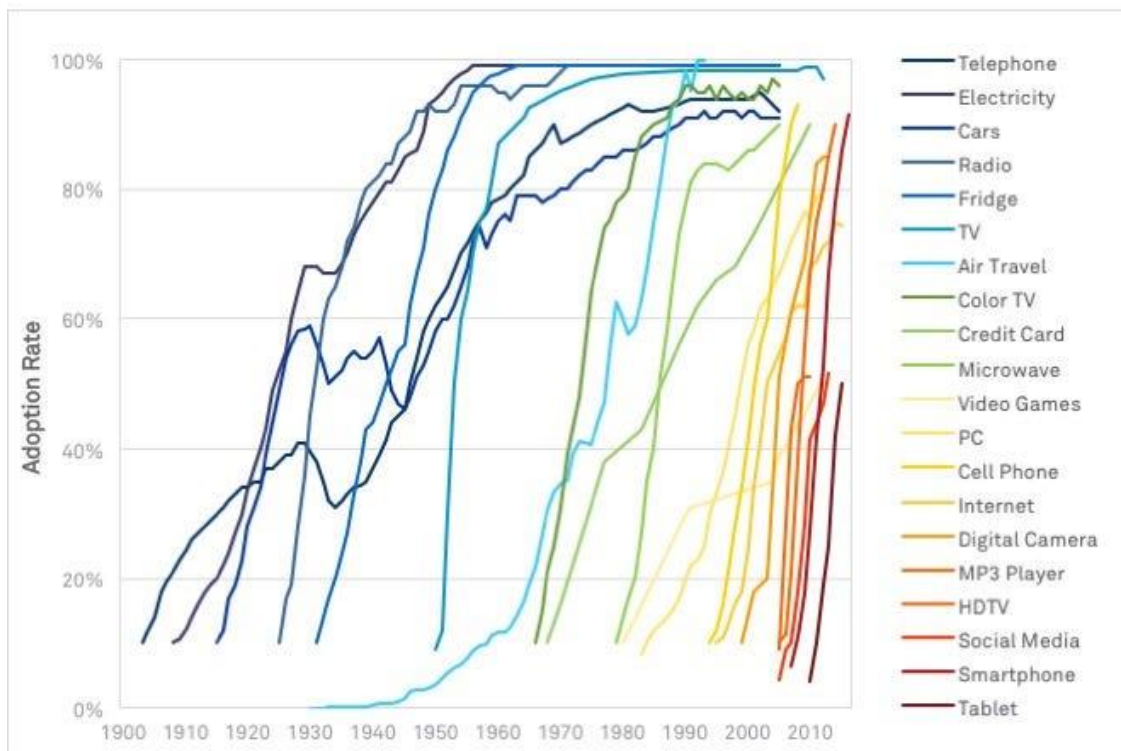
Source: BlackRock

The trend is evident that more and more companies will accelerate the use of cloud-based AI and ML software and services. Most companies gain AI capabilities through cloud-based enterprise software. Some use cloud-based development services to create AI applications, creating a massive demand for cloud-based platforms for AI and ML. The traditional tech companies have flocked to cloud-based AI and ML, with the top three highest shares being AWS, Azure, and GCP. And it has greatly accelerated the adoption of cloud-based AI and ML capabilities due to the epidemic of the past few years. Now the epidemic is largely over, but the share of cloud-based AI and ML is still growing at a high rate of 35% CAGR, as shown in Exhibit 2.2 [2]. So, the layout of AI and ML capabilities in the cloud is undoubtedly a long-term trend, not a short-term need. This chapter presents the evolution of AI and cloud computing separately and finally outlines the path of cloud-based AI development among tech companies.

Exhibit 2.2: Global artificial intelligence platforms market 2021-2025

Source: Technavio

2.1 AI and ML overview

2.1.1 AI and ML technology

In 1956 at the Dartmouth Artificial Intelligence Conference, AI was described as such: "Every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it." [3] In the AI field, there are several terms. Artificial intelligence is the largest collection, machine learning is a subset of artificial intelligence, and deep learning is a subset of machine learning, as shown in Exhibit 2.3 [4]. This thesis mainly focuses on AI and ML, which the three companies generally use. In short, the difference between AI and ML is that AI is the broader concept of machines being able to perform tasks in what we consider to be "intelligent" ways. ML is a current application of AI that revolves around the idea that we should be able to give machines access to data and let them learn on their own [4].

Exhibit 2.3: The relationship between AI, ML and DL
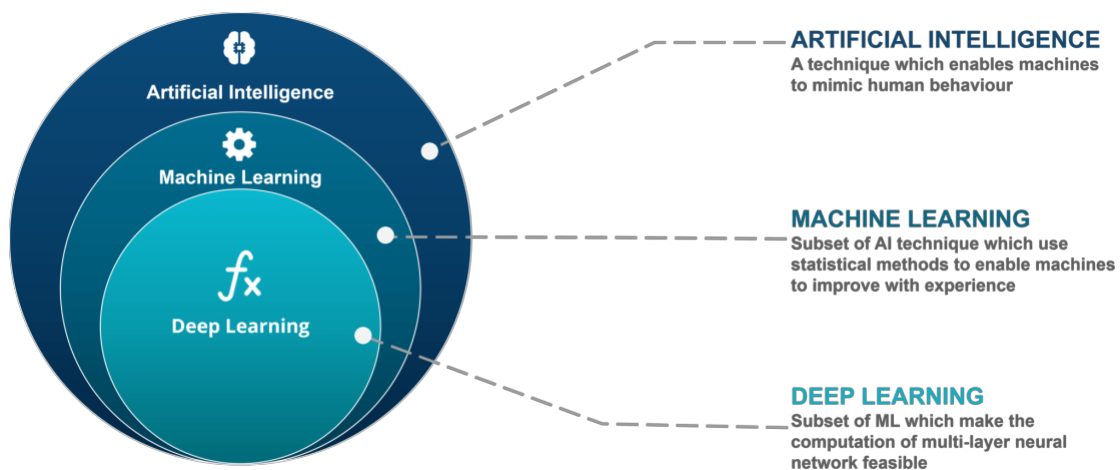
Source: Atul. AI vs Machine Learning vs Deep Learning, 2022

The three essential elements of AI are data, algorithms, and computing power, which have experienced several booms and busts in development history, as shown in Exhibit 2.4 [5].

Exhibit 2.4: AI development history
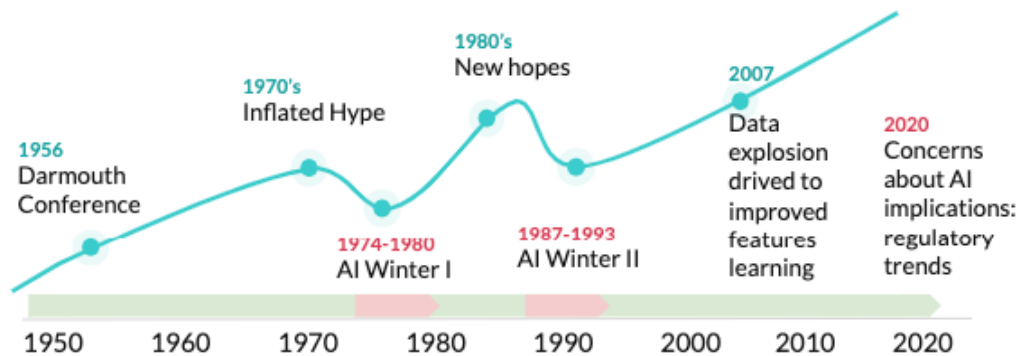
Source: Juan Murillo Arias. What should be taken into account if Artificial Intelligence is to be regulated? 2020

2.1.2 AI and ML applications

The primary AI and ML applications are speech, computer vision, and natural language processing, interacting through sound, images, and text in the same way humans perceive the world. Speech mainly includes speech recognition and speech synthesis, with typical applications such as dialogue systems and other voice interaction applications; computer vision mainly includes biometric recognition, image recognition and spatial recognition, with typical applications such as face recognition; natural language processing includes language interaction and semantic understanding, with typical applications such as machine translation. The nature of artificial intelligence capabilities can be divided into classification and prediction. In addition to individual

domain applications, AI can also be combined with multi-domain computer technology to enhance productivity.

From the maturity of the industrial segment, the most mature and widely used computer vision branch is the security field. Many artificial intelligence vision unicorns have been successfully incubated. Among them, Shang Tang Technology, as a security unicorn in the front-runner, the latest valuation in 2021 has reached 40 billion yuan. In real life, we can also feel the ubiquity of vision applications, such as mobile phone face unlocking. The combination of artificial intelligence and medical care has been a popular branch. From the perspective of supply and demand, quality medical resources cannot be evenly distributed, and the rapid growth of medical demand is difficult to meet. Artificial intelligence has huge scope in the field of medical imaging and assisted diagnosis. Combined with 5G technology, which solves the video bandwidth problem, new applications such as remote consultation are becoming increasingly mature. Another important area is new drug development, and since the epidemic, there have been many organizations using AI algorithms to accelerate vaccine development. There has also been rapid development in autonomous driving, with early AI companies focusing on autonomous driving, such as Waymo. The car market is huge in volume and high-frequency use. Combined with high technology such as artificial intelligence, the car of the future can be used as a terminal to form an extremely imaginative technology ecosystem.

The commercialization application of artificial intelligence is developing rapidly. AI technology has been applied in many fields such as finance, healthcare, security, education, transportation,

manufacturing, and retail, and the application scenarios are getting richer and richer, involving

all aspects of life, as shown in Exhibit 2.5 [6]. Based on the different preset conditions, such as

the completeness of digital infrastructure and the scale of IT investment in each industry, the

commercialization of AI is still taking the niche industry as a breakthrough and then developing

into a full industry chain ecosystem.

Exhibit 2.5: The Essential Landscape of Enterprise AI Companies (2020)
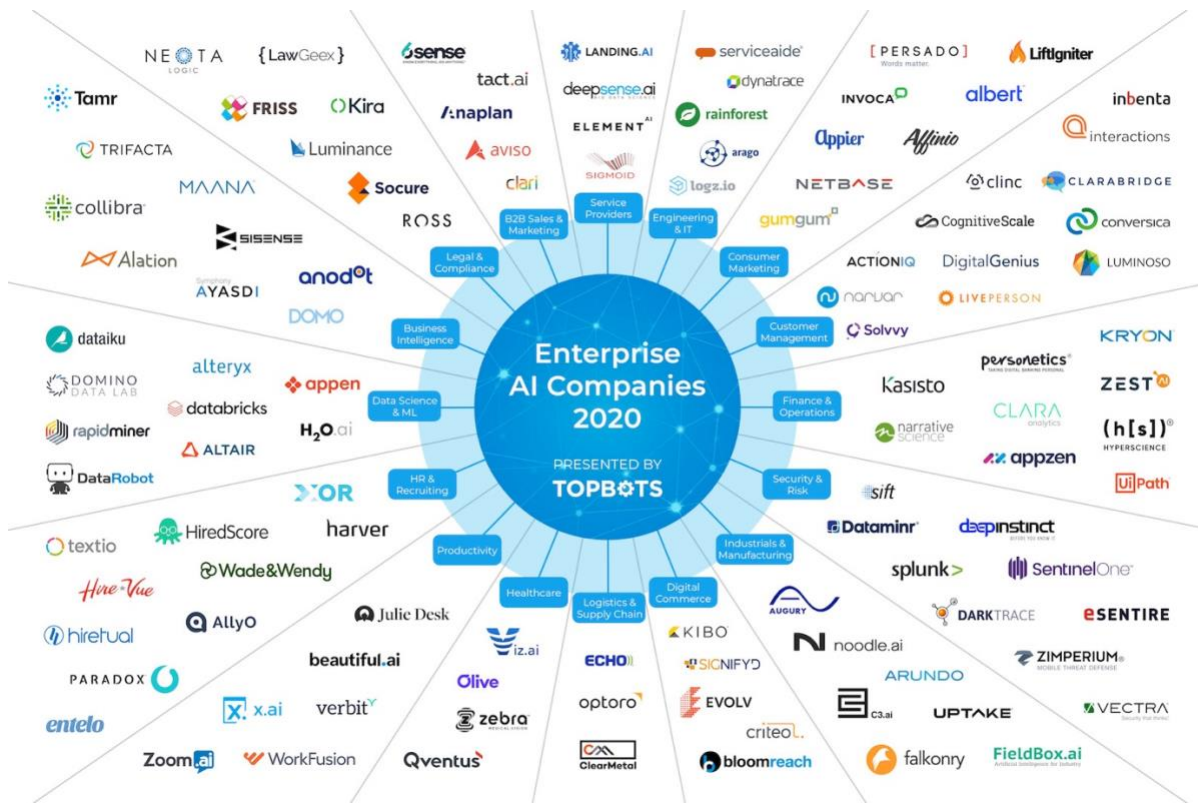
Source: Mariya Yao. Topbots, 2020

With the development of AI technology and applications, there are more and more areas like

those mentioned above. The commercialization of AI is becoming more and more prosperous,

thus increasing the demand for AI capabilities. The AI platforms of technology majors are playing

an increasingly large role. The main reasons are as follows: 1. SMEs cannot afford the high cost

of AI technology development and hardware purchase. 2. Compared with self-built AI capabilities,

the AI platform of cloud services is more flexible, cheaper, and more cost-effective. 3. The cloud

platform of technology majors is technologically advanced and ecologically complete so that you

can select the most suitable product in comparison.

2.2 Cloud computing overview and cloud-based AI and ML platform development history

2.2.1 Cloud computing overview

According to the literature [7], John McCarthy suggested in the 1960s that in the future,

computing would be done through public institutions. The idea of cloud computing gained

popularity in 2007 due to the rapid development of communication channels and the geometric

growth of business needs. In 2008, the term cloud computing was used for the first time by the

head of the US government. Since then, cloud computing has grown by leaps and bounds and

has penetrated various industries with its advantages.

For cloud-based AI and ML platforms, there are three layers. The relationship between the three

layers and related applications can be seen in Exhibit 2.6 [8].

Exhibit 2.6: The relationship between the three layers and related applications
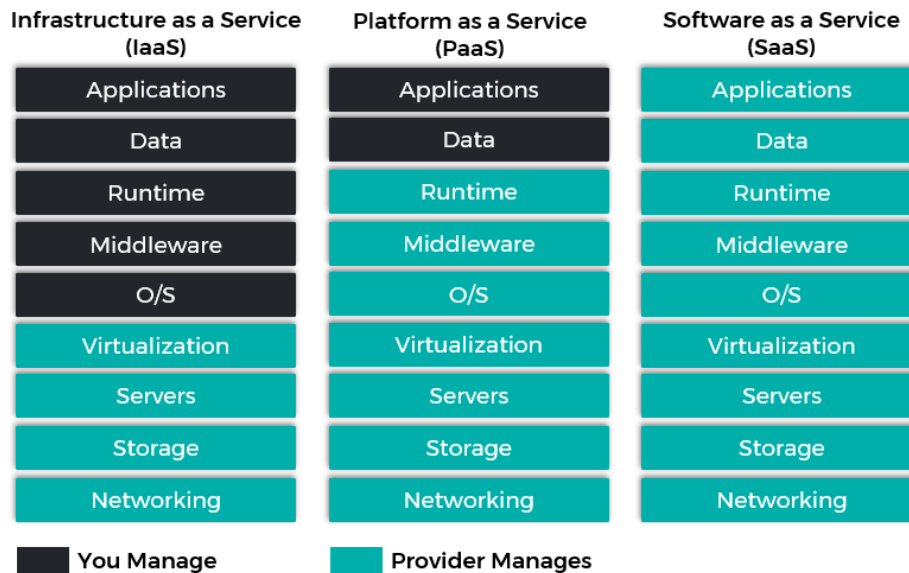
Source: Laura Vietmeyer. What are the Differences Between IaaS, PaaS and SaaS? 2020

The top layer is SaaS (Software-as-a-Service), which provides software services over the Internet. SaaS platform providers deploy application software on their servers. Customers can order services and products from SaaS platform providers via the Internet according to their actual needs and pay the vendors according to the specific services and products ordered.

The middle tier is PaaS (Platform as a Service), where a third party provides the application software platform. PaaS is primarily aimed at developers and programmers and allows users to develop, run and manage their applications without the need to build and maintain the platform associated with this process. PaaS can also be understood as an application of the SaaS model. However, the emergence of PaaS can accelerate the development of SaaS applications, such as personalized software custom development.

At the bottom is IaaS (Infrastructure as a Service), where IT infrastructure is offered to the public as a service over a network. In this service model, users do not have to build any related infrastructures such as data centers by themselves but use infrastructure services, including servers, storage, and networks, by renting.

There are four kinds of deployment options for a cloud strategy: public clouds, private clouds, hybrid clouds, and multi-clouds. It is important to choose the deployment solution that is right for your organization, but deployment solutions are not set in stone, and organizations can switch solutions as their business and technology needs evolve.

Private cloud: Owned by the user organization, it is a dedicated facility and resource within the enterprise. The enterprise's data and facilities are fully autonomous and controllable, and highly customizable but at a higher cost.

Public cloud. A form of product or service with shared, on-demand infrastructure and resource characteristics provided by a third-party provider. In a public cloud deployment, an enterprise leverages one or more types of cloud services, such as SaaS, PaaS, or IaaS, without relying on on-premises infrastructure. While inexpensive, it is less secure and does not facilitate large-scale data migration.

Hybrid cloud: A combination of public and private cloud services that provide consistency in operations and infrastructure. It can combine the common benefits of both public and private clouds but can be difficult to maintain and protect because the setup is more complex.

Multi-cloud. It consists of any combination of one or more public and private clouds as products and services. Many enterprises rely on more than one cloud provider. Enterprises can develop a product or service portfolio that perfectly fits their needs by picking from a menu of services offered by each provider. For example, they might use AWS for database servers, GCP to host virtual machines and run code in containers, and Azure to provide office productivity tools. While multi-cloud is flexible and has many advantages, switching between platforms and managing and maintaining them requires a higher threshold and is more complex.

2.2.2 Cloud-based AI and ML platform development history

For technology companies, it is the consensus to use cloud computing technology, combined with the accumulation of big data and the continuous development of AI capabilities, to establish a cloud-based platform for AI and ML.

AWS became the first cloud computing company to offer Infrastructure as a Service in 2008 and had been rolling out new services at a phenomenal pace. Since 2008, both hardware and software for cloud computing have developed rapidly as mobile communication technologies have gradually solved the problems of latency, speed, and network bandwidth. As the demand

for computing continues to surge, AI, big data, and other needs have become increasingly prominent, and companies have built their own AI and ML platforms, covering IaaS, PaaS, and some SaaS in all aspects and providing private, public, hybrid and multi-cloud deployment methods.

In addition to AWS, which has established a first-mover advantage through continuous technological innovation and iteration, customer-centric product polishing, and the creation of socio-economic benefits, Microsoft and Google, and other relatively late market entrants have also learned from Amazon's success and built their moats based on their company characteristics. The whole industry is booming.

Through more than a decade of development, the change in the market share of each cloud platform has become more and more apparent. As shown in Exhibit 2.7 [9], according to the Synergy Research Group report, from 4Q17 to 2Q21, counting the overall share of IaaS, PaaS, and Hosted Private Cloud, AWS is undoubtedly ranked first, and its share remains stable. Microsoft ranks second but has the fastest-growing share momentum compared to other companies. Next is Google, which is also growing steadily. We can see that the top three control 71% of the market, the dominance of cloud providers is more evident, and the cloud business is showing strong growth in all world regions.

Exhibit 2.7: Cloud provider market share trend

(IaaS, PaaS, Hosted Private Cloud)
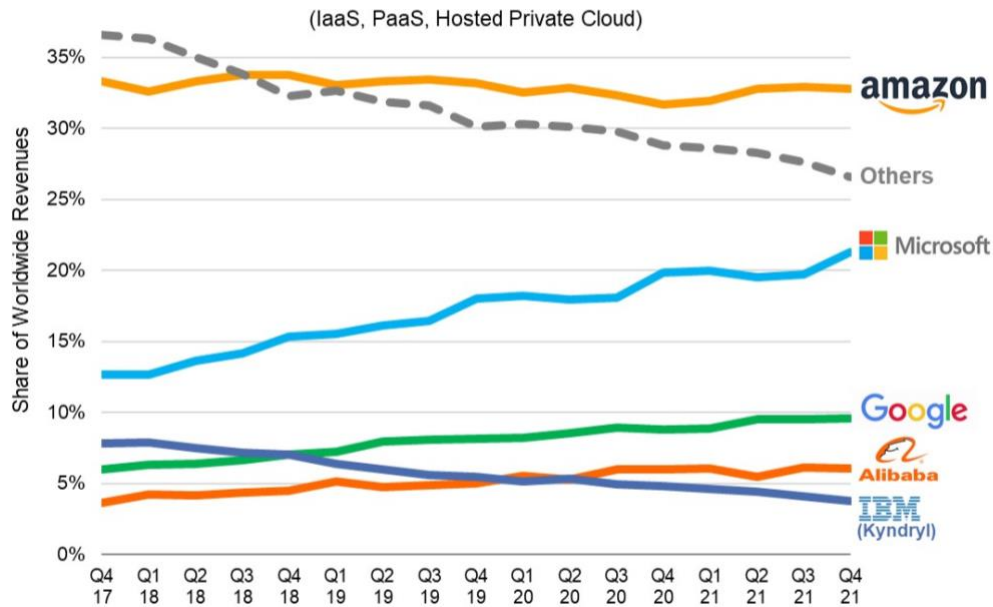
Source: Synergy research group, 2022

As for the AI and ML platforms, as they have evolved over the years to match user needs, end-to-end development machine learning platforms have now become mainstream, and a summary of the relevant platforms is shown in Exhibit 2.8 [10].

Most end-to-end platforms provide more than just a development environment and infrastructure for model deployment. Model lifecycle management, observability, end-to-end security, cost management, etc. are also provided, and even mainstream models, etc., are also provided with model libraries, i.e., matched with the various AI capabilities of the platform to give users the most convenient, efficient, secure, and stable user experience. And they have grown faster and faster in recent years.

Exhibit 2.8: Machine learning platforms by category
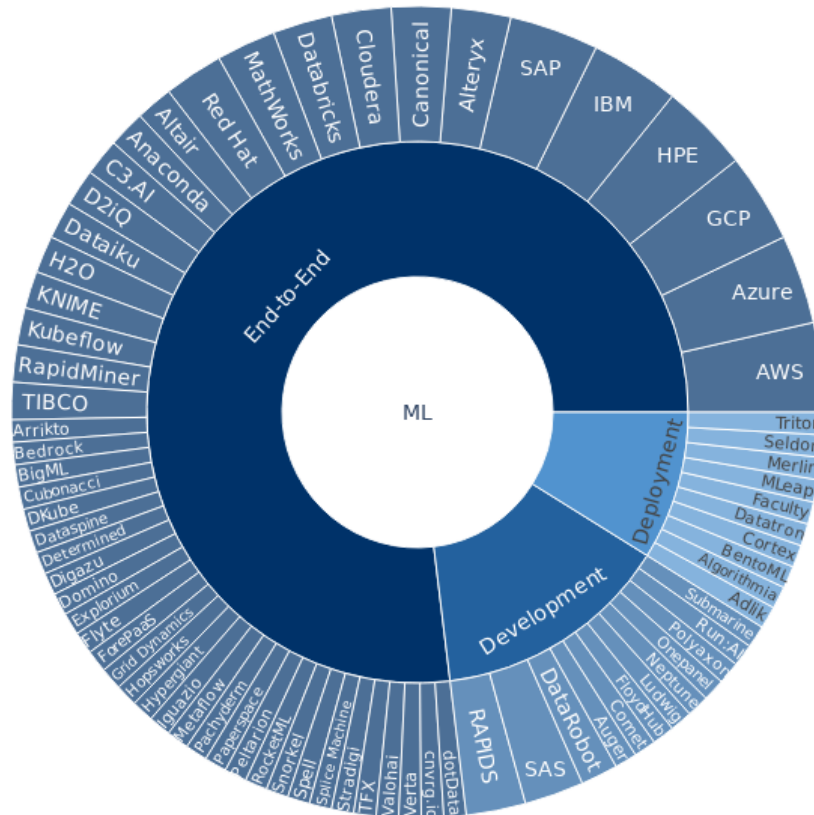
Source: Ian Hellström. Machine Learning Platforms in 2021, 2021

And now it can be booming and evolving many general features. For example, based on the needs of public and private clouds, cloud-based AI and ML platforms can mostly be deployed locally for security. And based on ease of use, many platforms support low-code or even no-code operations, such as visual drag-and-drop functionality. In addition to precipitating generic performance, the platform ecosystem is also extraordinarily active, such as technology companies providing Feature stores based on cloud platforms to join more complementors.

In the next few years, the global AI platform market is expected to have a CAGR of 35% from 2020 to 2025 and a significant increment in cloud-based, as shown in Exhibit 2.9 [11], so the competition for AI platforms is increasingly stimulated. A few key players will occupy most of the market share for the future competitive landscape. But even for the major technology companies, with a lot of financial, human, and material resources, the competitive strategy should be suitable for their characteristics to occupy more market share more robustly and quickly and gain excess revenue in the huge incremental volume.

Exhibit 2.9: Global artificial intelligence platforms market 2021-2025
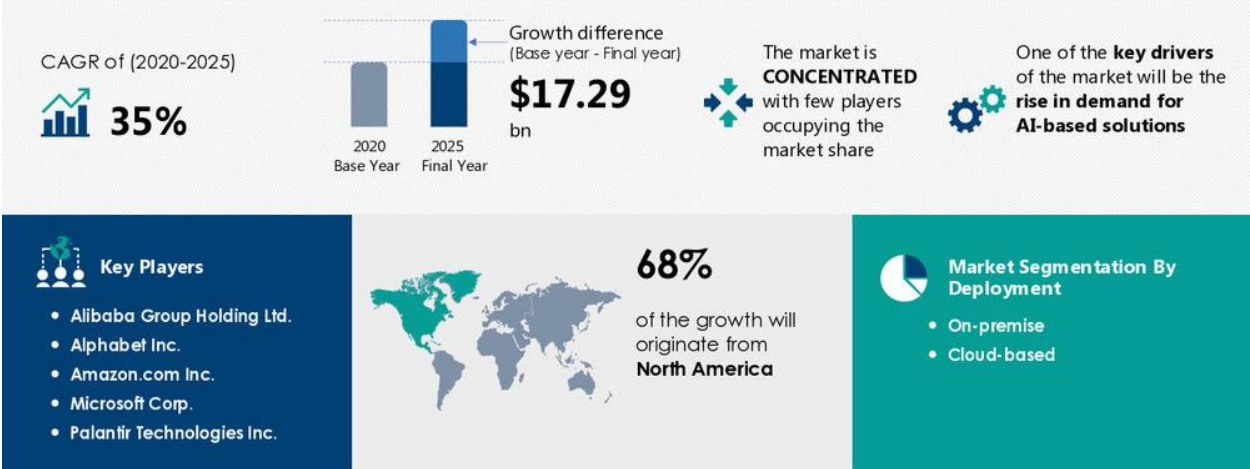
Source: Technavio. Artificial Intelligence Platforms Market Size to Grow by USD 17.29 Bn| Rise in demand for AI-based solutions to boost market growth, 2022

3. Comparative analysis of AI and ML at Amazon, Microsoft, and Google

This chapter mainly discusses AI and ML in Amazon, Microsoft, and Google about internal applications and external ecosystem. They are all big platform companies with different businesses and different business models. They dominate the public cloud space. AI and ML are essential components of each company, and with the development of digitalization, intelligence, and trends such as the metaverse, they are also an important development direction for the future. For each company, we first analyze the company's internal applications, then the company's external ecosystem, and finally a summary analysis of each company's strategic characteristics. APIs are an effective means to be used in both AI and ML-related businesses, both internally and externally. The introduction, tutorials, and API documentation on the official website are effective tools in AI and ML-related businesses. And the company's API inventory and open status can represent the company's existing business distribution and future development plan. In the subsequent chapters, we will go through the functional descriptions on the official websites and the documentation details of APIs for in-depth analysis.

3.1 Amazon Web Services

As you can see from Exhibit 3.1 [12], from the bottom up, AWS supports the entire stack of AI and ML capabilities, providing AI infrastructure, platforms, and services that are also compatible

with mainstream frameworks and software. In the base layer, the hardware side includes support such as relevant GPUs and CPUs, and the software is deeply integrated with mainstream AI frameworks such as TensorFlow and PyTorch. In the ML service layer, the core is SegeMaker, which is complemented by capabilities through Studio and Marketplace. In the AI service layer, there are separate modules for speech, text, and vision support and separate components integrated into relatively mature application domains.

Exhibit 3.1: The AWS ML stack
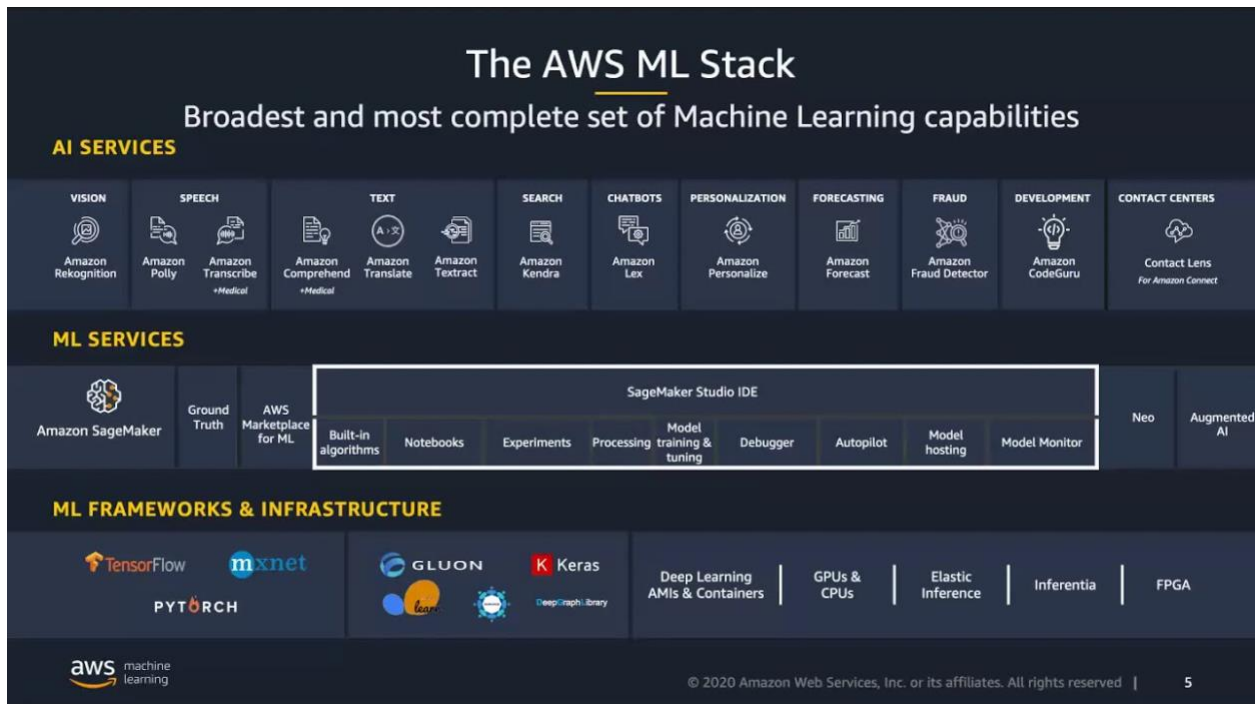
Source: AWS, 2020

We split the API into two parts based on the official API list and features. The first part includes AI and ML Services, as shown in Exhibit 3.2, which is based on ASR, CV, and NLP subdivision applications. After AWS integration, it provides mature API functions.

Exhibit 3.2: AWS AI and ML API modules for services

AWS	API Module	Description
AI Services	Comprehend	Extract insights about the content of documents without the need of any special preprocessing.
	Comprehend Medical	Comprehend Medical detects and returns useful information in unstructured clinical text.
	Forecast	A fully managed deep learning service for time-series forecasting.
	Fraud Detector	A fully managed service that helps you detect suspicious online activities.
	HealthLake	A Fast Healthcare Interoperability Resources (FHIR)-enabled patient Data Store.
	Kendra	A search service that enables users to search unstructured text using natural language.
	Lex	Building conversational interfaces into applications using voice and text
	Lookout for Equipment	Provides a conceptual overview of Amazon Lookout for Equipment.
	Lookout for Metrics	Helps you continuously find anomalies in business and operational data based on the same technology used by Amazon.com.
	Lookout for Vision	Find visual defects in industrial products, accurately and at scale.
	Monitron	An end-to-end system that detects abnormal behavior in industrial machinery.
	Panorama	Improve their operations by automating monitoring and visual inspection tasks at the edge.
	Personalize	Real-time personalization and recommendations.
	Polly	Text-to-Speech (TTS) cloud service that converts text into lifelike speech.
	Rekognition	Add image and video analysis to your applications.
	Textract	Add document text detection and analysis to your applications.
	Translate	Translate text to and from English across a breadth of supported languages.

	Transcribe	Provide transcription services for your audio files and audio streams.
	DeepComposer	An artificial intelligence (AI)-enabled music keyboard that provides you with a hands-on learning experience to explore generative learning.
	DeepLens	A connected HD camera developer kit with a set of sample projects to help developers learn machine learning concepts using hands-on computer vision use cases.

Source: AWS website, 2022

The second part covers the platform capabilities of AI and ML, as shown in Exhibit 3.3. SageMaker is the core of a powerful machine learning platform, providing end-to-end model build, train, and deploy the whole process.

Exhibit 3.3: AWS AI and ML API modules for platform functions

AWS	API Module	Description
AI Platform	SageMaker	Build and train machine learning models, and then deploy them into a production-ready hosted environment.
	Augmented AI (A2I)	Build the workflows required for human review of ML predictions.
	CodeGuru	Provides intelligent recommendations for improving application performance, efficiency, and code quality in Java applications.
	DevOps Guru	Generates operational insights to help you improve the performance of your operational applications.
	Elastic Inference	Attach low-cost GPU-powered acceleration to many Amazon machine instances in order to reduce the cost of running deep learning inference.

		Equip machine learning practitioners and researchers with the infrastructure and tools to accelerate deep learning in the cloud at any scale.
	Deep Learning AMIs	
	Deep Learning Containers	A set of Docker images for training and serving models in TensorFlow, TensorFlow 2, PyTorch, and MXNet.
	DeepRacer	A reinforcement learning (RL)-enabled autonomous 1/18th-scale vehicle with supporting services in the AWS Machine Learning ecosystem.
	Apache MXNet on AWS	An open-source deep learning framework that allows you to define, train, and deploy deep neural networks on a wide array of platforms, from cloud infrastructure to mobile devices.
	Machine Learning	Build smart applications, including applications for fraud detection, demand forecasting, targeted marketing, and click prediction.

Source: AWS website, 2022

In terms of AI and ML industrial application, AWS has integrated the three industry solutions of financial services, manufacturing, retail, and healthcare, as shown in Exhibit 3.4.

Exhibit 3.4: AWS AI and ML industry cases

AI and ML industry cases	Description
Healthcare and life sciences	Unlock hidden potential in your health data with HIPAA-eligible ML—for petabyte-scale analysis and fast unstructured text and speech documentation.
Industrial and manufacturing	Detect abnormal machine behavior, spot defects, enable predictive maintenance, and improve operations with purpose-built Industrial AI services—no ML experience required.
Financial services	Innovate with ML across banking, payments, capital markets, and insurance sectors to improve customer experience with personalization, and virtual assistants and prevent online fraud.

Source: AWS website, 2022

3.1.1 Internal applications

In his 2014 Amazon annual shareholder letter, Jeff Bezos mentioned that Amazon now has three businesses that it has pursued all its life: Prime, Marketplace, and AWS, which are Amazon's three core businesses:

- Prime - Amazon's membership service.

  If you pay Amazon $139 a year for membership, you can enjoy a range of outstanding value services. A large part of it is Amazon's e-commerce.

- Marketplace - a platform for third-party sellers.

  On Amazon's platform, in addition to various Amazon goods, all other sellers can also be stationed on Amazon, selling their stuff directly.

- AWS - Amazon's cloud service.

  Provides enterprise-level cloud services to businesses.

The three pillars of business above constitute the flywheel effect of Amazon, just like Exhibit 3.5 [13]. The logic is that the Prime members have high cost-effective services, dramatically increasing customer loyalty. Amazon allows third-party merchants to sell products and allows customers to choose from a much larger selection of goods. As Amazon's customers grow, more third-party merchants will be willing to open stores on Amazon. When Amazon has enough customers and sales, Amazon's bargaining power over upstream suppliers will be greatly increased. When Amazon's goods get cheaper, third-party sellers will also control costs or sell something that Amazon itself does not sell. When third-party sellers use Fulfillment by Amazon

(FBA) services to host their goods in Amazon's logistics center, which will increase the range of goods, the Prime membership is more valuable. When Amazon handles enough goods every day, the cost of logistics will also fall. AWS can provide cloud services for any merchants and third-party businesses. So that you sell goods on Amazon and use Amazon's FBA services to do logistics and run your own IT systems on AWS, it is much harder to change platforms.

Exhibit 3.5: Amazon flywheel effect

Source: Catie Grasso. The Amazon Flywheel Explained: Learn From Bezos' Business Strategy, 2020

To sum up, the more merchants using AWS cloud service business and the more merchants using FBA logistics business, the more goods and services users can choose from, and the better value Prime membership will be. So, Amazon gets more customers, which further improves overall efficiency and lowers the price of goods and services on the platform. The Amazon flywheel can spin at a fast pace once again.

AWS was born formally because Amazon's internal systems could not support the company's growth, and the technical team tried to solve the internal service problem more effectively. So, internally, there is an excellent big customer for AWS in Amazon's interior business. This customer has enabled the AWS platform to gain deep insight into demand and continually iterate on its technology and services. And the flywheel effect is the most significant competitive advantage of AWS. As AWS grows better, it will empower the e-commerce business, thus facilitating the flywheel to turn up. According to a critical component of the 2021 earnings report, AWS AI and ML platforms assign three main blocks of Internal business: e-commerce, advertising, and hardware.

For e-commerce, Amazon Global Store covers 17 major sites worldwide and currently has over 300 million active users worldwide. Artificial intelligence is beneficial in large-scale distributed operation management. We will briefly introduce how AWS's AI and ML platform can empower mainly in three directions: marketing, logistics, and supply chain.

1. Marketing.

   One of the applications is the system records the consumer's past purchase behavior, search records, browsing records, etc. The recommendation algorithm will understand a single consumer's consumption habits and consumer preferences to carry out more accurate product recommendations.

Another application is intelligent price adjustment, through real-time inventory automatically develop pricing strategy, such as Amazon own shop's daily dish surplus. On the one hand, the company can reduce the inventory of daily-clearance goods, and on the other hand, consumers can buy the freshest goods of the day at the most affordable price.

There is also an intelligent marketing system. The system will automatically analyze the user's purchasing habits and purchase history when they finish eating and using a specific item to automatically send the push of relevant articles to the user at a more appropriate time.

2. Advertising

In the fourth quarter of the 2021 earnings report, although the advertising business currently accounts for only 7% of total business revenue, it is undoubtedly the fastest-growing part of Amazon's various business areas and AWS, with growth in the past few quarters even up to 88%. At the same time, advertising has also become the fourth most significant source of revenue [14].

The monetization model for advertising is to attract external ad placements through Amazon's massive traffic and high conversion rates, provide bidding rankings for third-party sellers on the e-commerce platform to increase exposure, and attract various placements in brick-and-mortar stores [14]. Recommendation systems in AI and ML are critical. This is because the recommendation system can make accurate recommendations for users based on their behavioral habits, consumption habits, and other user profiles, thus increasing

conversion rates, and high conversion rates lead to high revenue, which is crucial for advertisement placement.

3. Hardware

In the field of intelligent hardware, due to its huge upfront investment in voice assistants and cloud computing, Amazon also has a first-mover advantage in the IoT and cloud markets, forming an integrated structure that includes infrastructure, technology platforms, services, and product markets, and has always maintained a leading position in the smart home market. In the past five years, in the U.S. smart speaker market, the number of Amazon Echo installations accounted for up to 69% of the total number of installations [14]. In recent years, Amazon has also continued to iterate its own hardware products. Echo belongs to a dialogue system that is related to AWS ASR and NLP abilities.

Amazon has been exploring new products and active layouts in the field of robotics, such as the Astro smart home robot. The robots usually are a combination of several AI and ML abilities for different sceneries, such as CV for vision and ASR for voice control. In addition, Amazon is also in space exploration, electric vehicles, and other frontier areas in advance of the layout. Space company Blue Origin has completed a manned space flight, and investment in electric pickup truck company Rivian was also successfully listed [14]. And all these explorations are based on powerful and comprehensive AWS AI and ML abilities.

3.1.2 External ecosystem

AWS ranks number one market share in cloud computing and offers business (ToB) and customer (ToC) products and services. ToC business covers a relatively small part, and ToB business is the main one. Technology companies such as Meta, financial services such as Goldman Sachs and Nasdaq, pharmaceutical companies such as Pfizer and Gilead, and consumer brands such as Adidas and BestBuy are all large enterprises using AWS cloud services. In this part of the business growth rate, ToB business is relatively stable. The potential market is significant.

In addition to large companies, as we said before, Amazon's third-party SMEs are an important part of the flywheel effect. AWS cloud services benefit greatly from economies of scale. The more people use it, the lower those upfront costs and fixed costs are evenly spread out. Combined with economies of scale, when SMEs build their cloud business on AWS, they will improve the efficiency of their own business and reduce costs; after AWS has enough SME customers, it can reduce operating costs and precipitate better services and form industry methodologies, which will feed back to SME customers, thus driving the flywheel.

For enhancing the openness of the ecosystem, AWS offers two approaches. The first is a partner network chosen from a global community of trusted cloud partners with diverse expertise. The robust AWS partner community has more than 100 partners from more than 150 countries. Over 100,000 partners from more than 150 countries. This dynamic and diverse partner network can help you deliver greater value to your business, increase agility, and reduce costs. The second is

the AWS Marketplace, a curated digital catalog that makes it easy to find, test, buy and deploy third-party software. And there are topic areas and industry use cases.

By opening AWS up to the outside world, AWS can be cheaper. And it will be harder for anyone to compete with it, especially since AWS ranks first in the market size and absolute growth volume. The economies of scale and flywheel effect will be more obvious.

3.2 Microsoft Azure

Azure's AI and ML platform offers several product modules, as shown in Exhibit 3.6. It also summarizes high-frequency applications and industry AI use cases based on the cloud and the edge and considers other open-source frameworks and software libraries while providing its own AI infrastructure, platforms, and services. It also provides the Azure marketplace, which can access top partner solutions, optimize procurement, and streamline deployment through the commercial marketplace. Azure for Independent Software Vendors (ISVs) is also established to innovate, grow, and scale with cloud computing you can trust. Like AWS, Azure's feature modules are comprehensive, and Azure is user-friendly from a product perspective, with application-oriented layers.

Exhibit 3.6: Azure AI and ML product modules

Azure Applied AI Services
Specialized services that enable organizations to accelerate time to value in applying AI to solve common scenarios

Azure Cognitive Services
Add cognitive capabilities to apps with APIs and AI services

Azure Machine Learning
Build, train, and deploy models from the cloud to the edge

Azure Cognitive Search
Enterprise scale search for app development

Azure Bot Services
Create bots and connect them across channels

Azure Databricks
Design AI with Apache Spark™-based analytics

Kinect DK
Build for mixed reality using AI sensors
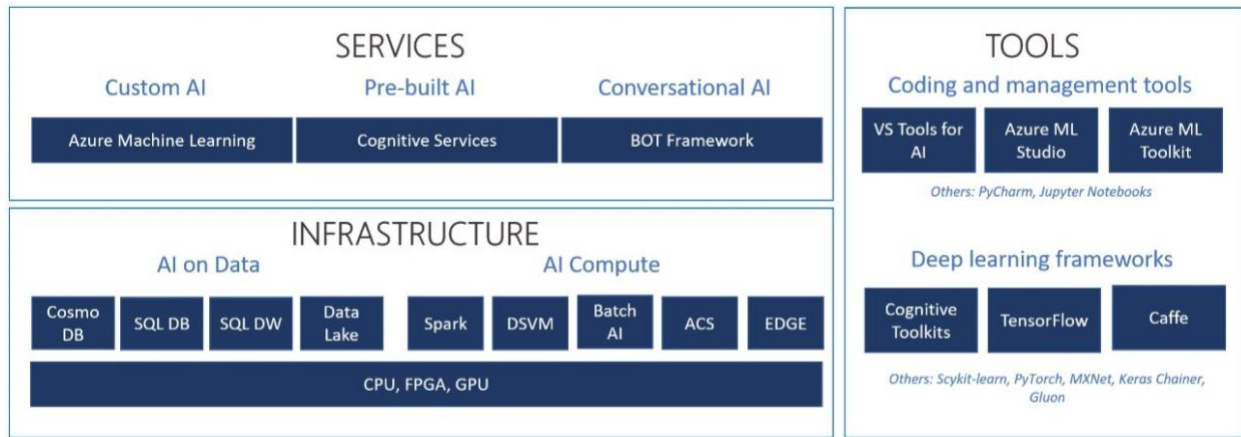
Azure OpenAI Service
Apply advanced language models to a variety of use cases

Source: Azure website, 2022

According to the same Infrastructure, Platform, and Service classification as the AWS framework, the framework is shown in Exhibit 3.7 [15] below.

Exhibit 3.7: Azure AI and ML framework

Source: Dr Rabi Prasad Padhy. A Closer look at Microsoft AI Platform, 2019

Azure AI and ML platform has four parts by functions, as shown in Exhibit 3.8, from the underlying AI Infrastructure to the end-to-end Azure Machine Learning platform, to Azure Cognitive Services, which provides APIs for CV, ASR, and NLP mainstream application domains, to the easy-to-use Azure Applied AI Services. Azure not only provides its own AI infrastructure, platform, and services but also considers other open-source frameworks and software libraries.

Exhibit 3.8: Four parts of Azure AI and ML platform by functions

Azure AI/ML	Description
Azure Applied AI Services	Modernize business processes with task-specific AI
	Accelerate development with built-in business logic
	Run responsibly with security both in the cloud and the edge
Azure Cognitive Services	Easily access sophisticated AI models
	Build with AI services to achieve CV, ASR, and NLP applications
	Deploy anywhere from the cloud to the edge with containers
	Get started quickly and customize solutions
Azure Machine Learning	Develop with your choice of tools
	Create and deploy models at scale
	Innovate responsibly with built-in responsible capabilities
	Build your way for open-source frameworks and languages
AI Infrastructure	Access large-scale infrastructure
	Enable hybrid and multi-cloud deployments
	Access a breadth of AI hardware

Source: Azure website, 2022

In the AI application scenario, the high-frequency applications based on the cloud and the edge are extracted: Machine Learning, Knowledge Mining, Conversation AI, Document process automation, Machine translation, and Speech transcription, as shown in Exhibit 3.9.

Exhibit 3.9: Azure high frequency AI and ML scenarios based on the cloud and the edge

Make AI real	Description
Machine Learning	Build, train, and deploy models
	Use the latest tools and frameworks
	Provide low-code and no-code tools
Knowledge Mining	Uncover latent insights from documents, images, and media
	The only cloud search service with built-in AI capabilities
Conversation AI	Develop enterprise-grade conversational AI experiences
	Build multilingual and multimodal bots for nearly any scenario
Document process automation	Turn documents into usable data
	Accelerate document processing
Machine translation	Translate text and documents in real time or in batches
Speech transcription	Transcribe speech to text
	Produce natural-sounding text-to-speech voices

Source: Azure website, 2022

In terms of AI and ML industrial application, Azure has integrated the four industry solutions of financial services, manufacturing, retail, and healthcare after summarizing and refining several single-point solutions in the same industry, as shown in Exhibit 3.10.

Exhibit 3.10: AI and ML industrial use cases

AI/ML industry module	Description
Financial services	Combat financial crime
	Improve customer experiences
	Modernize core banking
Manufacturing	Automate quality control
	Practice proactive maintenance
	Enhance worker safety
Retail	Improve customer experiences
	Optimize customer assistance
	Optimize stock replenishment

	Enable predictive care
Healthcare	Improve operational outcomes
	Accelerate innovation

Source: Azure website, 2022

From the official website and documentation, Azure mainly strengthens the ease of use and feature completeness. The overall framework is shown below in Exhibit 3.11 [16].

Exhibit 3.11: Azure AI, ML and deep learning technologies
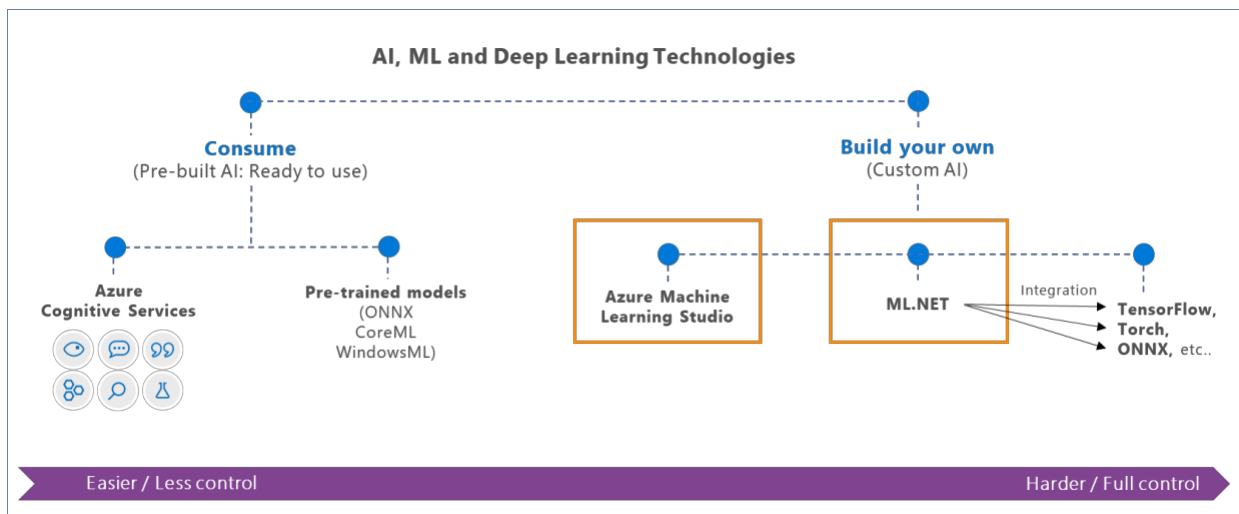
Source: Develop S. Custom AI Models with Azure Machine Learning Studio and ML.NET, 2019

Azure provides Pre-built AI modules such as pre-built code modules and model libraries, industry solution methodologies, and existing multi-category projects and services for ease of use. Users can directly invoke or fine-tune them to make AI applications more efficient and convenient. It can also take the form of low or no code, using a graphical interface for interaction. And Azure provides video and documentation tutorials for the entire process, which can be reached quickly

on the website. For functional completeness, it provides platform functions to realize

personalized AI requirements, and provides end-to-end lifecycle support, including four modules:

prepare data, build and train models, validate and deploy, and manage and monitor shown in

Exhibit 3.12. It is also compatible with various cutting-edge and mainstream frameworks and is

easy to expand.

Exhibit 3.12: Azure AI and ML End-to-end support functions

End-to-end support	Description
Prepare data	Data labeling
	Data preparation
	Datasets
Build and train models	Notebooks
	Automated ML
	Drag-and-drop designer
	Experiments
	Visual Studio Code and GitHub
	Compute instance
	Open-source libraries and frameworks
Validate and deploy	Managed endpoints
	Pipelines and CI/CD
	Pre-built images
	Model repository
	Hybrid and multi-cloud
	Optimize models
Manage and monitor	Monitor and analyze
	Data drift
	Error analysis
	Audit
	Policies
	Security
	Control costs

Source: Azure website, 2022

3.2.1 Internal applications

Exhibit 3.13: The Microsoft business model
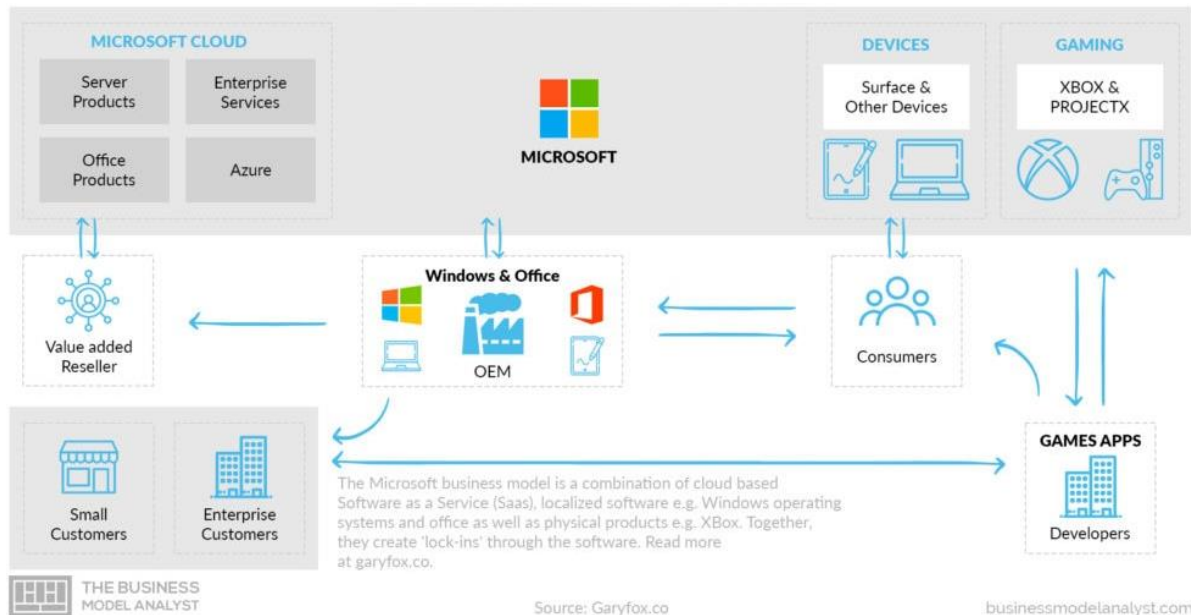
Source: Daniel Pereira. Microsoft Business Model, 2022

As shown in Exhibit 3.13 [17], there are many Microsoft business modules that cover a wide range

of topics. In 2015, Microsoft underwent a major internal reorganization, restructuring the entire

group from five business units to three major business units.

1. Productivity and Business Processes

    Microsoft Productivity and Business Processes is a division that includes Microsoft's

    productivity products, communications products, and information services, such as Office,

    Outlook, and Skype, which are available in both enterprise and personal editions. There is

also LinkedIn, a professional social network, and Dynamics, a cloud-based solution for enterprise applications such as ERP or CRM.

2. More Personal Computing

Products and services created to improve the user experience, such as Windows, Bing search, cellphones, Surface tablets, and game consoles such as Xbox.

3. Intelligent Cloud (Azure)

According to the two major business modules within Microsoft, two things can be seen: because Windows and other productivity-related software are very popular, Microsoft has accumulated a lot of corporate customer resources and has many head enterprise-level customers, and it has unparalleled advantages in operating systems, databases, Office, servers, etc. At present, Microsoft's AI function has been successfully integrated with Office365, Dynamics365, LinkedIn, and other products and functions.

Microsoft also has a lot of experience with products for individual consumers. In addition to its accumulation in software, Microsoft also has a deep accumulation in computers, platforms, cell phones, Xbox, and other hardware. For example, Microsoft developed a function called "HomeHub" for Windows 10, which enables the combination of traditional PC and AI, allowing users to control Philips Hue, Nest, Insteon, Winl and Samsung SmartThings through the Microsoft Nana voice assistant, helping the traditional Windows 10 to achieve product intelligence.

The business scenario of Microsoft product matrix is very complex, so the comprehensive capabilities of ToB, ToC, software, and hardware are very comprehensive, corresponding to the comprehensive capabilities of Azure's AI and ML platform, which can provide a series of perfect and compatible overall solutions of IaaS, PaaS, and SaaS. This is also one of the outstanding advantages of Azure's AI and ML platform.

3.2.2 External ecosystem

As the world enters the "cloud" era, enterprises of all kinds are once again facing major changes in their IT systems. In the cloud era, the first to stand out is Amazon's AWS cloud service. AWS has been analyzed above, because of its business ecosystem, it mainly wins the small and medium-sized customers, including many startups. Because AWS is easy to deploy and reasonably easy to use, any new, small company with uncomplicated IT systems can migrate to it quickly, at a low cost in terms of both money and time.

But for large enterprises, especially those with decades of history in the U.S., migrating their entire systems to a new "cloud" system is a massive undertaking. Target was originally a ten-year customer of Amazon AWS but eventually felt that it was more convenient to carry the system on its own servers, so it decided to leave AWS and build its own IT infrastructure. It took Amazon more than a year to help Target migrate all its architecture and data to its own servers, which reflects the fact that AWS still has something missing in terms of meeting the IT systems of midsize and large enterprises.

The IT systems of these medium and large enterprises are mainly supported by Microsoft, which has been a long-standing vendor. Microsoft has been a long-standing supplier, so it leveraged and built on its previous accumulation of ToB business to make products that large enterprise customers most urgently need. Integrating the various needs of customers to provide a complete solution is the ToB "hybrid cloud" strategy that Microsoft is focusing on.

Like AWS, most of the business services are public cloud. It helps you set up servers and a variety of infrastructure and cloud services like water and electricity at any time to call. With Amazon AWS, a small store can increase server capacity in minutes to withstand the holiday rush during Christmas and then cancel it once New Year's Day is over, with little to no need to know any complex IT skills or set up an IT department. But the cost is that your various data exist on Amazon. This is perfectly acceptable for a small store. Still, some large customers often need a "private cloud" and need to build their own data center. All facilities, data, maintenance, etc., are internal, internal management and isolated from the outside world. For example, for large banks such as enterprises, their IT systems cannot be completely entrusted to Amazon because a lot of sensitive information on the public cloud is not standard.

Microsoft has launched a "hybrid cloud" service, which seamlessly combines public and private clouds to help enterprises, especially large enterprises with that Microsoft has always had the best relationship, to use flexible tandem. For example, for banks, the most sensitive information can be physically isolated from the Internet, while the less sensitive information is simply and efficiently handled on the public cloud. And bringing it all together to help companies land,

implement and maintain is Microsoft's forte. It is also possible to make full use of the accumulation of previous cooperation with various companies to develop competitiveness.

Amazon AWS mainly provides IaaS and PaaS products and is small in SaaS. Microsoft Cloud can provide both Office 365, Dynamics, and other SaaS products but can also offer rich products from IaaS and PaaS levels. In addition, Microsoft IaaS, PaaS, and SaaS products all use the same kind of data model, which minimizes compatibility issues and thus creates a strong synergy effect.

So, Azure's advantages are mainly two: First, the experience and accumulation of long-term cooperation with large companies before let Azure understand more about the needs of large companies and provide more convenient services. Second, the accumulated advantage in SaaS allows the overall unification of IaaS, PaaS, and SaaS, thus making the product experience easier to use. What's more, Azure also has a third-party software market, which can explore innovative apps in the marketplace and see what other SaaS providers have built with Microsoft.

3.3 Google Cloud

Google's AI capability is also one of the strongest, accumulating deep, and the company attaches great importance to it, constantly investing company resources, which is one of Google's core competencies. Google's software and hardware ecosystem are outstanding, especially the combination of software and hardware of TPU and TensorFlow so that the model training results and efficiency have been greatly improved. Google has also been one of the driving forces in

leading the academic advancement of AI algorithms, such as ranking first in NeurIPS 2021 paper winning/receiving companies, and the Transformer, which is very famous and widely used in the field of algorithms, also comes from Google. Therefore, GCP's AI and ML platform has strong technical support.

GCP AI and ML platform provides full-flow development capabilities, including from data processing to model development, training, tuning, and deployment, and can also be combined with Google's own AI framework and software ecosystem and provides a library of pre-built AI models and code modules, and a low-code module AutoML with a low barrier to entry. The overall architecture is shown in Exhibit 3.14 [18].

Exhibit 3.14: GCP AI platform framework
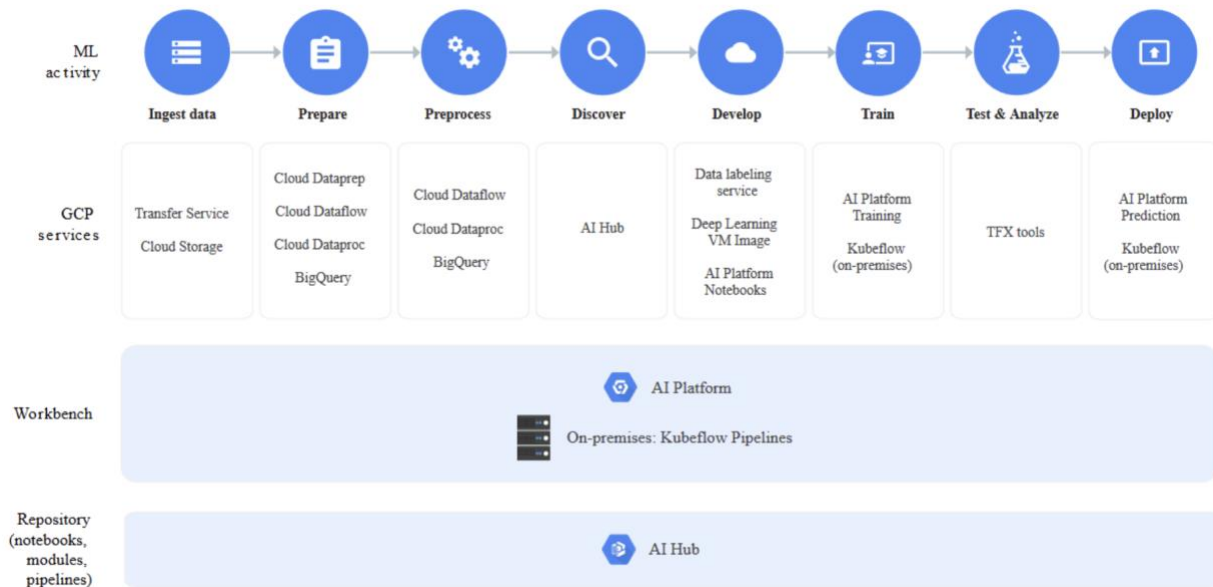
Source: PAT RESEARCH, Google AI Platform

A significant difference between AWS and Azure is that GCP's official website is laid out from a technical developer's perspective. At the same time, AWS and Azure are more focused on product and service capabilities and industry implementations. GCP's AI and ML platform can be divided into three parts at the products and services level: AI for Data Scientists, AI for Developers, and AI infrastructure. GCP provides a complete suite of data management, analytics, and machine learning tools to generate insights and unlock value from data in the AI for data scientists. It also offers all the tools data scientists need to unlock value from data. From data engineering to ML engineering, TensorFlow to PyTorch, GPUs to TPUs, data science on GCP helps your business run faster, smarter, and at planet scale. The main applications are shown in Exhibit 3.15.

Exhibit 3.15: GCP AI and ML API modules for data scientists

GCP AI/ML	API Modules	Descriptions
AI for Data Scientists	Vertex AI	Accelerating data preparation
		Scaling data
		Training and experimentation
		Model deployment
	Vertex AI Workbench	Rapid prototyping and model development
		Developing and deploying AI solutions on Vertex AI with minimal transition.

Source: GCP website, 2022

For the AI for developers' section, GCP provides the low-code platform AutoML but does not support drag-and-drop. It also provides high-frequency capabilities based on CV, NLP, and ASR, and singles out high-frequency applications such as Translation, as shown in Exhibit 3.16.

Exhibit 3.16: GCP AI and ML API modules for developers

GCP AI/ML	API Modules	Descriptions
AI for Developers	AutoML	Building custom machine learning models in minutes
		Training models specific to your business needs
	Cloud Inference API	Indexing and loading a dataset consisting of multiple stored data sources
		Executing Inference queries over loaded datasets
		Unloading or canceling the loading of a dataset
	Cloud Natural Language	Applying natural language understanding to apps with the Natural Language API
		Training your open ML models to classify, extract, and detect sentiment
	Dialogflow	Creating natural interaction for complex multi-turn conversations
		Building and deploying advanced agents quickly
		Building enterprise-grade scalability
	Media Translation (Beta)	Delivering real-time speech translation directly from your audio data
		Scaling quickly with straightforward internationalization
	Speech-to-Text	Creating automatic speech recognition
		Transcribing in real time
		Empowering Google Contact Center AI
	Text-to-Speech	Improving customer interactions
		Engaging users with voice user interface in devices and applications
		Personalizing communication
	Timeseries Insights API (Preview)	Gathering insights in real time from time series datasets
		Detecting anomalies while they are happening
		Handling large scale datasets and running thousands of queries per second
	Translation AI	Delivering seamless user experience with real-time translation
		Engaging your audience with compelling localization of your content

		Reaching global markets through internationalization of your products
	Video AI	Extracting rich metadata at the video, shot, or frame level
		Creating your own custom entity labels with AutoML Video Intelligence
	Vision AI	Using ML to understand images with industry-leading prediction accuracy
		Training ML models to classify images by custom labels using AutoML Vision

Source: GCP website, 2022

The AI infrastructure, from hardware to software, GCP has its unique advantages. TensorFlow has been iteratively developed for many years, and with TPU hardware, training effectiveness and efficiency are much improved. It has also been advantageous in large-scale industrial deployments. Detailed features are shown in Exhibit 3.17.

Exhibit 3.17: GCP AI and ML API modules infrastructure

GCP AI/ML	API Modules	Descriptions
AI Infrastructure	Deep Learning Containers	Prototyping your AI applications in a portable and consistent environment
	Deep Learning VM Image	Accelerating your model training and deployment
	GPUs	Speeding up compute jobs like machine learning and HPC
		Accelerating specific workloads on your VMs
	TensorFlow Enterprise	Boosting enterprise development with long-term support on specific distributions
		Scaling resources across CPUs, GPUs, andCloud TPUs
		Developing and deploying TensorFlow across managed services
	TPUs	Running cutting-edge machine learning models with AI services on Google Cloud

		Iterating quickly and frequently on machine learning solutions
		Building your own ML-powered solutions for real-world use cases

Source: GCP website, 2022

Although GCP does not directly indicate the industry user case, it gives the AI solution module functionally consistent with the industry use case. There are four sceneries, as shown in Exhibit 3.18.

Exhibit 3.18: GCP AI and ML solutions

GCP AI/ML solutions	Products and services	Description
Contact Center AI	Speech-to-Text	Transform your contact center with AI technology. Increase operational efficiency and personalized customer care from the first "Hello."
	Text-to-Speech	
	Natural Language	
	Dialogflow	
Document AI	Document AI	Improve your operational efficiency by bringing AI-powered document understanding to unstructured data workflows across a variety of document formats.
	Base OCR	
	Enterprise Knowledge Graph enrichment	
	Human in the Loop	
Intelligent products (Preview)	Intelligent Products Essentials	Rapidly build products using AI at the edge and analytics in the cloud.
	Pre-built app templates	
Product Discovery	Recommendations AI	Increase conversion rate across digital properties that help brands to deliver consumer experiences.
	Vision Product Search	
	Retail Search	

Source: GCP website, 2022

3.3.1 Internal applications

Exhibit 3.19: Google product portfolio
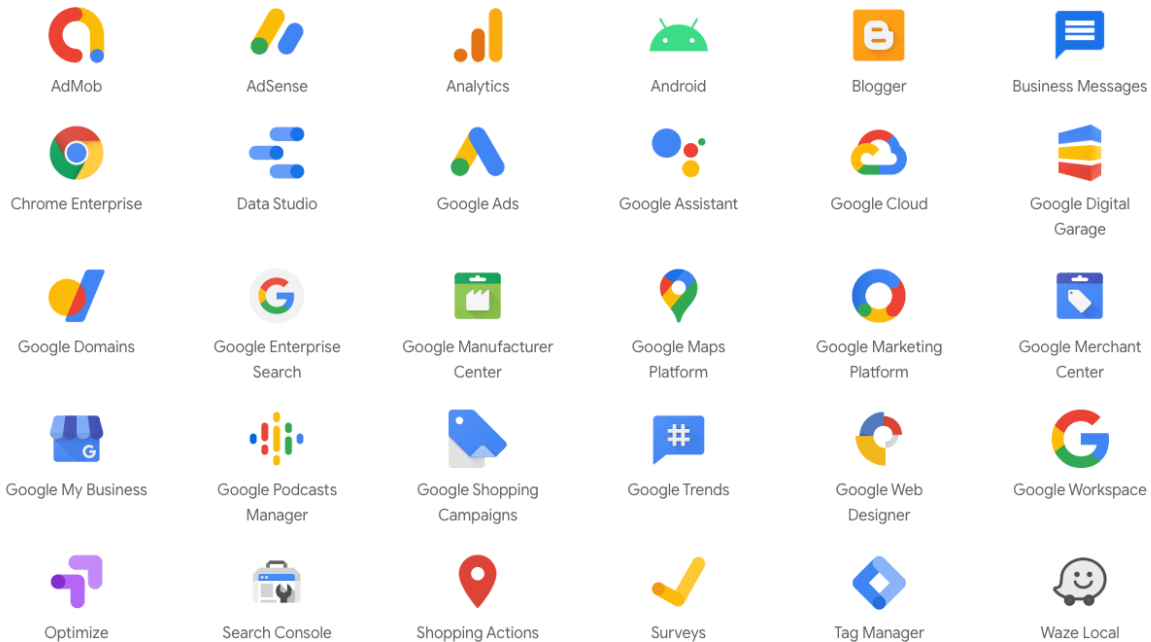
Source: Mahesh Mohan. Over 271 Google Products & Services You Probably Don't Know, 2021

As the above Google product portfolio in Exhibit 3.19 [19] shows, Google has many products, and Google is the company with the largest number of products with "billion" users, such as Google Search, Gmail email, YouTube video, Google Maps, Chrome browser, Android, and Google Play app store. Google's advertising accounts for most of Google's profits, and the only way for Google to share its fixed costs and attract advertisers is to have the largest number of users possible. So, Google can somehow be called a company that earns advertising revenue by providing services.

GCP's AI and ML capabilities can support a variety of internal applications in the infrastructure layer are, to use GPUs or TPUs. in the platform layer, TensorFlow, and in the product and service layer to match the module according to different needs. For example, in Google's core advertising business, to use the recommendation system for personalized push, Google speaker needs Speech-to-Text, Text-to-Speech, and Dialogflow for interaction, and Google Translate needs Translation AI for translation, etc.

Unlike AWS, which focuses on SMBs to drive the growth flywheel, or Azure, which focuses on large enterprise customers, Google didn't see the cloud as a particularly important external business at first but rather as a tool to serve its own business, develop AI, and build a developer ecosystem. However, GCP still maintains the third-largest market share every year. And in Google Cloud Next '21, Google Cloud CEO Thomas Kurian said that "we'll be announcing even more product innovations and partnerships at Next '21 to help organizations accelerate their cloud journey" and used Vertex AI Workbench as the example to build and deploy machine learning models faster. With the expected increasing pace of commercialization in the AI and ML cloud market, the market increment has been significant. Google is increasingly focusing on GCP.

As AWS and Azure firmly occupy the top two positions in the cloud platform, GCP is under pressure to compete, and doing so with differentiation is the key to winning. Focusing on technology development and empowering applications to build barriers may be a viable path to enhance the competitiveness of GCP's AI and ML platforms because of DeepMind. Since its inception, DeepMind has created several AI milestones.

2016 saw the DeepMind-developed AlphaGo program defeat South Korean Go champion Lee Se-dol 4-1. 2017 saw DeepMind release AlphaGo Zero, which defeated AlphaGo 100-0 after three days of self-training. In 2020, the "AlphaFold" AI system participated in a competition by the Critical Assessment of Structure Prediction (CASP) on how to calculate the 3D structure of protein molecules and achieved unprecedented levels of prediction accuracy. In 2022, DeepMind released an AI that can magnetically control the plasma configuration in tokamaks to help achieve controlled fusion [20].

The significant advances have undoubtedly contributed greatly to the progress of the AI and ML fields, of which DeepMind is a pioneer and trailblazer in the world. AI and ML platforms are largely technology-driven, coupled with products that best fit the needs of users in order to continue to meet them. Google's business and products are very diversified, including hardware and software, IaaS, PaaS, SaaS, and so on, which will probably provide scenarios and data for DeepMind's research, and DeepMind's research results can be distilled and abstracted into common components integrated into AI and ML platforms, thus forming a positive cycle. James Murphy, a researcher at DeepMind, recently published DeepMind's 15 major advances in AI for 2021, covering many aspects of AI research. Some of these research results have the potential to be integrated into the platform, such as Massive Multi-task Learning, which can be directly invoked as a library of pre-built models for the platform.

In summary, when facing competition from strong rivals AWS and Azure, and when the first two occupy a large market share, Google's internal DeepMind and related extremely strong AI and ML research capabilities may be a competitive advantage for GCP's AI and ML platform.

3.3.2 External ecosystem

GCP's AI and ML capabilities are comprehensive, from TensorFlow, a deep learning framework, to AutoML, based on Google's advanced migration learning technology and neural architecture search technology, to BERT, a natural language processing pre-training model. Google has been leading the development of the technology. At the application level, GCP also has a complete layout. At the infrastructure IaaS level, Google released a proprietary chip TPU for machine learning, designed for Google's deep learning framework TensorFlow. Compared with CPU and GPU operations, it limits the flexibility of registers, controls, and operations in exchange for efficiency and higher operational density. At the PaaS level, the AI Hub one-stop platform is responsible for managing and operating complex machine learning environments, helping users to achieve platforming. At the SaaS level, Google provides many Cloud API base components, including AutoML customized models and various APIs for vision, language, conversation, structured data, etc. Combined with global-based infrastructure, a large amount of data, and powerful computing power, AI and machine learning can maximize the strengths.

Based on this, although Google does not have the advantage of not having as many SMEs as Amazon does, nor does it have the long-term valuable ToB experience Microsoft has accumulated

large serving companies, Google has still won many customers in a homogeneous and competitive market, such as partnering with HSBC, one of the world's largest banking and financial services organizations, to provide ML for anti-money laundering and predictive credit scoring solutions. It also worked with the United Services Automobile Association (USAA), a group of Fortune 500 financial services companies, to train the organization's engineers on ML technologies applied to specific insurance scenarios. eBay also used GCP to train its ShopBot digital assistant. Overall, GCP has many fewer external users than AWS and Azure but fits the market volume.

In addition, in the incremental market, as mentioned before, the technology advantage, AI and ML technology, is now developing rapidly. Google, as the leader in AI and ML technology development, will naturally be the first to attract more external users if it can be the first to integrate the new technologies into GCP's AI and ML platform.

3.4 Comparative analysis of AWS, Azure, and GCP

In summary, all three platforms can support the full stack of AI and ML functions, and all provide AI infrastructure, platforms, and services from IaaS, PaaS, and SaaS, covering the entire business from the bottom up. And there are separate modules for speech, text, and vision support, and all have opened separate components in relatively mature application areas. A summary of the products and services of the three companies' AI and ML platforms is shown in Figure 3.20. AWS is larger than both Azure and GCP in terms of functionality and maturity. Azure focused more on

ease of use, highly refined by functional modules, and then expanded level by level. GCP is more developer-oriented, with a list of features from a developer's perspective. Each company has a different business and a different strategic focus.

Exhibit 3.20: AWS, Azure, and GCP AI/ML platform products and services

	AWS	Azure	GCP
AI/ML	SageMaker	Azure Applied AI Services	AutoML
	Augmented AI (A2I)	Azure Cognitive Services	Cloud TPU
	CodeGuru	Azure Machine Learning	Cloud Translation
	Comprehend	AI Infrastructure	Cloud Vision
	Comprehend Medical		Contact Center AI
	DevOps Guru		Deep Learning Containers
	Elastic Inference		Deep Learning VM Images
	Forecast		Dialogflow
	Fraud Detector		Document AI
	HealthLake		Speech-To-Text
	Kendra		Talent Solutions
	Lex		Text-To-Speech
	Lookout for Equipment		Vertex AI
	Lookout for Metrics		Vertex AI Data Labeling
	Lookout for Vision		Vertex AI Edge Manager
	Monitron		Vertex AI Feature Store
	Panorama		Vertex AI Matching Engine
	Personalize		Vector similarity searches
	Polly		Vertex AI Model Monitoring
	Rekognition		Vertex AI Pipelines
	Textract		Vertex AI Predictions
	Translate		Vertex AI Tensorboard
	Transcribe		Vertex AI Training
	Deep Learning AMIs		Vertex AI Vizier
	Deep Learning Containers		Vertex AI Workbench
	DeepComposer		Vertex Explainable AI
	DeepLens		Vertex ML Metadata
	DeepRacer		Video Intelligence API

	Apache MXNet on AWS Machine Learning		

The three platforms' integrated and collated industry solutions are shown in Exhibit 3.21, in which Azure contains industry solutions of AWS, all of which are divided by industry. But GCP's AI solutions are slightly thin, more like a collection of use cases.

Exhibit 3.21: AWS, Azure, and GCP AI solutions

Platform	AWS	Azure	GCP
Industry Module	▪ Healthcare and life sciences ▪ Industrial and manufacturing ▪ Financial services	▪ Financial services ▪ Manufacturing ▪ Retail ▪ Healthcare	▪ Contact Center ▪ Document ▪ Intelligent Products ▪ Product Discovery

In terms of internal application and external ecosystem, all three are used a lot because they are large technology companies with many products and applications, and AI and ML can be applied in various directions. However, there are many differences according to the business gap of different companies. Amazon mainly grows the flywheel ecosystem related, internally supporting the huge application of e-commerce and externally providing AI and ML capabilities to many SMEs. At the same time, through the rotation of the flywheel effect, to build a deep competitive advantage.

For Microsoft, the advantage is that it has a lot of experience and channels facing large enterprise users, and this part of the ability can be reused in the sales of cloud services. Microsoft can quickly

close the gap with AWS in a short period of time from the fact that it already has many head

enterprise-class customers, and its advantages in operating systems, databases, Office, servers

and other aspects are unparalleled. Now AWS's advantage is in small customers. Microsoft's

advantage in medium and large customers cannot be shaken. So, only these two can get large-

scale profits currently. Other latecomers do not have these advantages, naturally there is no very

strong motivation for All IN the development of cloud computing.

Google does not take the cloud as its particularly important external business, but only its own

business services, the development of AI, and building developer ecosystem tools. And the

reason why Google Cloud was established and developed is out of the consideration of Google's

overall product matrix integrity and is not a real source of profit for Google. Although Google has

been investing in the cloud, unless there is a landmark breakthrough in technology and thus the

formation of technical barriers, a short time should not see signs that Google can have an

outstanding competitive advantage. But on the other hand, with the current investment, Google

Cloud is still growing fast, firmly occupying the third position and increasing its share.

4.Strategic analysis based on development trends

As seen in Exhibit 4.1 [14], AWS, Azure, and GCP remain in the top three of the cloud market, and their individual shares are gradually growing, with a clear aggregation effect at the head. As we know from Exhibit 2.9 above, the global AI platform market in the next few years is growing very rapidly, which is a definite megatrend and will pay off handsomely. Therefore, it is important for all three platforms to adopt a suitable competitive strategy to maintain high growth. In addition to the existing characteristics and advantages of the three companies mentioned in the previous chapter, we also need to consider possible competitive strategies afterwards based on the changing business models of technology companies' cloud platforms and future explosive growth points.

Exhibit 4.1: Global Cloud Infrastructure Service Provider Market Share, Q4 2017 - Q3 2021
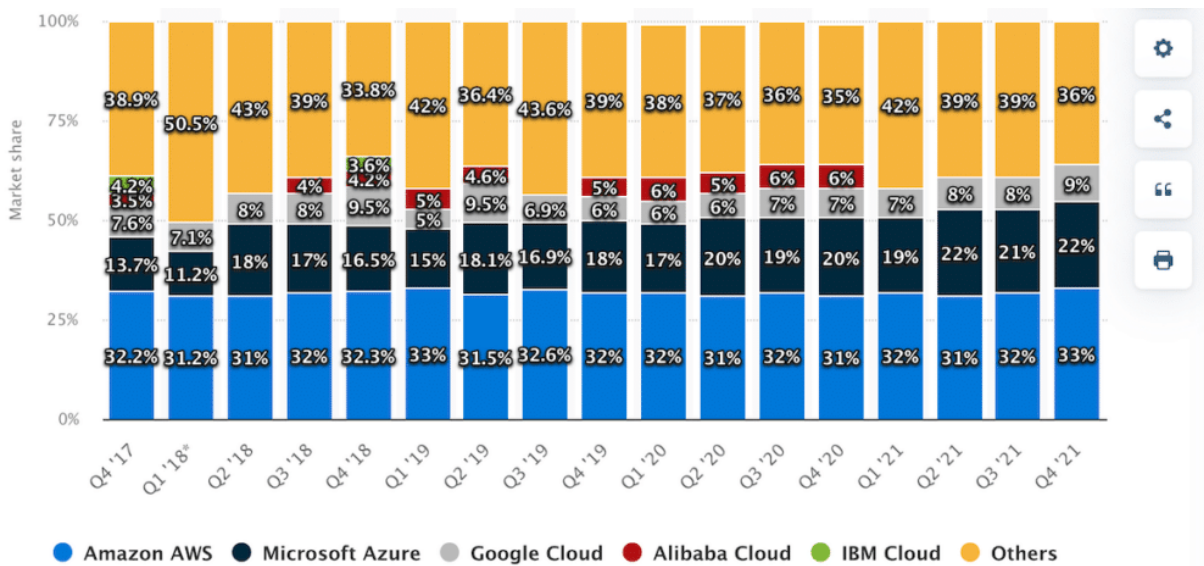
Source: 硅星人. '繁荣了 20 年的亚马逊，"中年危机"还未到来', 2022

4.1 Future technology platform Business Model and Competitive Strategy

With their technology, capital, and first-mover advantages, large technology companies are rapidly growing into giant AI platform companies, accelerating the monopoly of the market and industry. There is no denying that the AI platforms of large companies have empowered the commercialization of AI across industries through advanced technology accumulation and easy-to-use product forms.

As the world becomes increasingly digital, tech companies are making themselves more and more important through ecosystems. Examples include server clouds, ad networks, app stores, operating systems, social platforms, and more, as shown in Exhibit 4.2 by SingularityNet [21]. The rise of cloud computing has made this ecosystem possible, and almost all successful startups are expected to use the services of existing tech industry oligarchs. As cloud platforms continue to evolve and begin to integrate with emerging industries, companies without AI talent will find it difficult to operate effectively in a smart economy. They need to partner with a leading cloud platform. Because "more data = more accurate models = better products = more users = more data", the big companies have a clear competitive advantage and do not allow emerging companies to share the cake with them, while emerging companies can only serve as their own ecological complement. So, the only viable option for startups and emerging industry companies is to take advantage of the AI and ML services offered by the tech giants. That's why it's important for the three companies to maintain their market share and position in the top three.

Exhibit 4.2: The tech oligopoly ecosystem
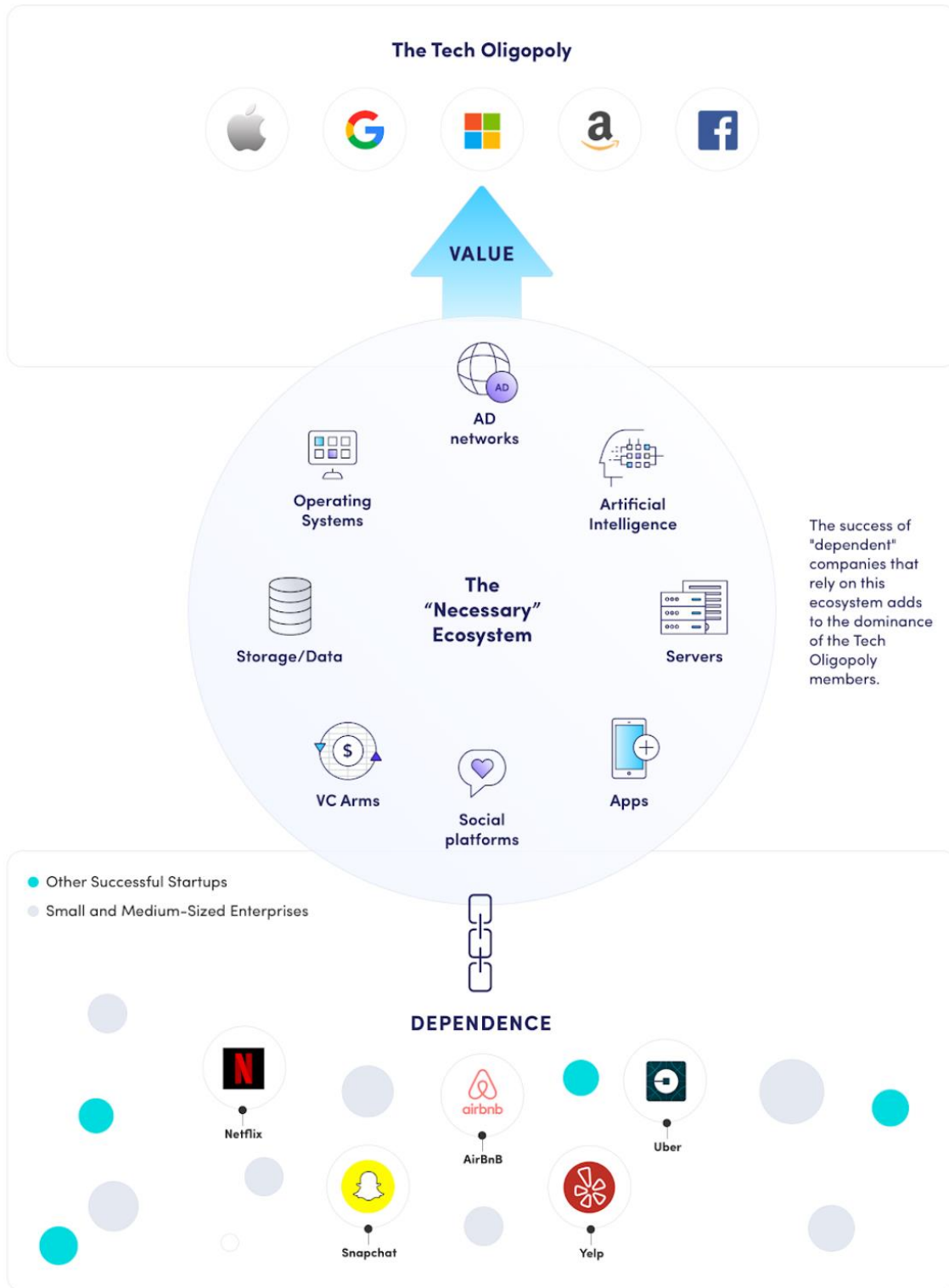
Source: SingularityNet

While the oligopoly ecosystem can hinder the growth of small and medium-sized enterprises, it is a considerable competitive advantage for the leading cloud platform companies. But this system also can better serve the user. Amazon often reduces prices to attract more users, and constantly through the ecological growth of its own capacity boundary can better serve this goal, so that the ecological and flywheel effect continue to develop.

Based on the above platform ecosystem, small and medium-sized companies will complement the platform's capabilities and serve users together with the platform, the business model for cloud-based AI in the future may be S2b2c. S refers to the provisioning platform, b refers to the small and medium-sized companies, and c refers to the customer, no matter a company or an individual. C is not served directly through one big B but through many small b's who then use S's provisioning platform to complete the service [22]. This would have been one of the possible models for the future of e-commerce, but it also lends itself particularly well to AI and ML platforms.

The prerequisite for S2b2c is that it must create much more value than if the small b or big B served c directly. Firstly, when small b serves c, it must call on service provided by S: S cannot just provide some kind of SaaS (Software as a Service) tool. It must provide some value-added services based on the integration of the upstream supply chain to help b serve c better. Secondly, for S, the process of small b serving c must be transparent to it, i.e., S can participate and give real-time feedback to improve S's service to small b. To achieve this, firstly, the process of small b serving

c must be online; secondly, S and small b have to collaborate automatically to better serve c through online and software [22].

Let's take an example of a possible application of an existing AI and ML platform. Let's say I want to build a dialect version of a conversation system through one of the three platforms. But I, as a consumer, would not use the relevant AI and ML technologies and platform features, so I got a company to do it. Since the AI and ML platform did not have the dialect corpus requested by the customer, the company trained a dialect version of the dialogue system based on the AI and ML platform using Speech and NLP modules with its own corpus and fine-tuned models to meet the consumer's requirements. In this process, the AI and ML platform is S, the company is b, and the consumer is c.

In the highly competitive landscape of cloud platforms, differentiated play is one of the very good means to compete. This S2b2c model, for c-consumers, meets the needs of users; for b-intermediate companies, it increases a single transaction; for S-the platform, more cases will help precipitate different industries and scenarios of generic module capabilities but also promote the marketplace partners' more prosperous. The platform can guide positively promote this model to develop better and faster, such as providing use cases and tutorials, providing incentives for excellent use cases, etc. Based on this, the future small and medium-sized companies will participate more deeply in the platform ecosystem of the head AI and ML platform, and together they will provide more comprehensive and flexible products and services for consumers.

For the three companies analyzed in this paper, Amazon has accumulated the smallest and medium-sized enterprises and has the advantage of users. However, the S2b2c business model is more like a SaaS service. Only in SaaS that S and b can continue to iterate with each other. At this point, Microsoft and Google have accumulated more SaaS and are competitive.

4.2 Promising trends and competitive analysis

With the development of cloud platforms, the need for AI and ML industry solutions is becoming more and more evident. Currently, the various AI and ML platforms offer solutions for a few domains, as shown previously in Exhibit 3.21. But the demand for AI and ML, like electricity, is obvious for all aspects of applications, and if the platform has well-integrated functional modules, it will be a big hit. It can bring new users to the platform, and the new use cases provided by new users will further iterate the platform's industry module functions, achieving a two-way promotion effect.

But AI and ML industry solutions, although the demand is great, the current commercialization to achieve mature and migratable difficulties, many are single project solutions, it is difficult to form industry methodologies. Both AI/ML platforms and companies in verticals are facing this problem. Though the entire field is trying, Large-scale commercialization of AI and ML will still be a long and tortuous process. Before refining the generic commercialization module, the applicable conditions of AI commercialization must be figured out, after which it is possible to

scale up. Based on actual use cases experience, there are several significant and pervasive constraints to commercialization.

1. Sufficient high-quality structured data.

   AI and ML algorithm training is based on big data, and most of the scenarios must be structured data, that is, data with labels that can identify features, in order to be fully trained by the model to play value.

2. Bounded scenes.

   The progress of AI and ML in infinite open scenes is very immature, such as the highest level of autonomous driving, but most of the relatively closed scenes have clear goals and mature applications.

3. Matching algorithms.

   After the data base and clear objectives, there should be corresponding algorithms to match them. Through the algorithm training data to reach the classification or prediction results.

4. Positive return on investment.

   AI and ML can now be applied to many fields, but due to the cost of human resources, arithmetic costs, and other consumption of practitioners, the return on investment may not necessarily have a positive return, so it is also a very important factor to consider.

In general, the commercialization of AI and ML is not mature now, except in a few areas. There are problems such as insufficient data accumulation, high operation cost, and difficulty guaranteeing the implementation effect. There are also policy and other comprehensive factors of constraints in the implementation process. For example, the privacy and security of personal data, user awareness and acceptance of AI and ML applications, and restrictive government policies, will also limit the speed of commercialization. And this is almost a general problem that will be faced in the starting stage of the industry and enterprises. But because it is difficult for SMEs to solve the problem of large-scale commercialization directly and there is a massive demand in the market, this is the time for the platform to play a role. If it can successfully integrate the industry commercialization module, it will significantly benefit the industry, the platform, and the related companies.

The S2b2c mentioned above may be a valid path. However, it also needs to focus on a few specific industries. Even though it is a big platform, the company's resources are limited, and it is essential to focus on the big things. When selecting an industry, AI adoption can be evaluated by assessing the vertical industry through the intrinsic demand (use case value, AI adoption readiness, etc.) and the ease of entry (competition, analytical transparency requirements, etc.), as shown in Exhibit 4.3 [23].

After the Intrinsic demand and ease of entry are met, the potential for large-scale commercialization is also considered. In the judgment process, the following three factors need to be considered: The ability to accumulate successful use cases in various aspects of a field, to

refine commonalities precipitated into common functions, and to integrate into platform modules.

Exhibit 4.3: AI and ML vertical priorities
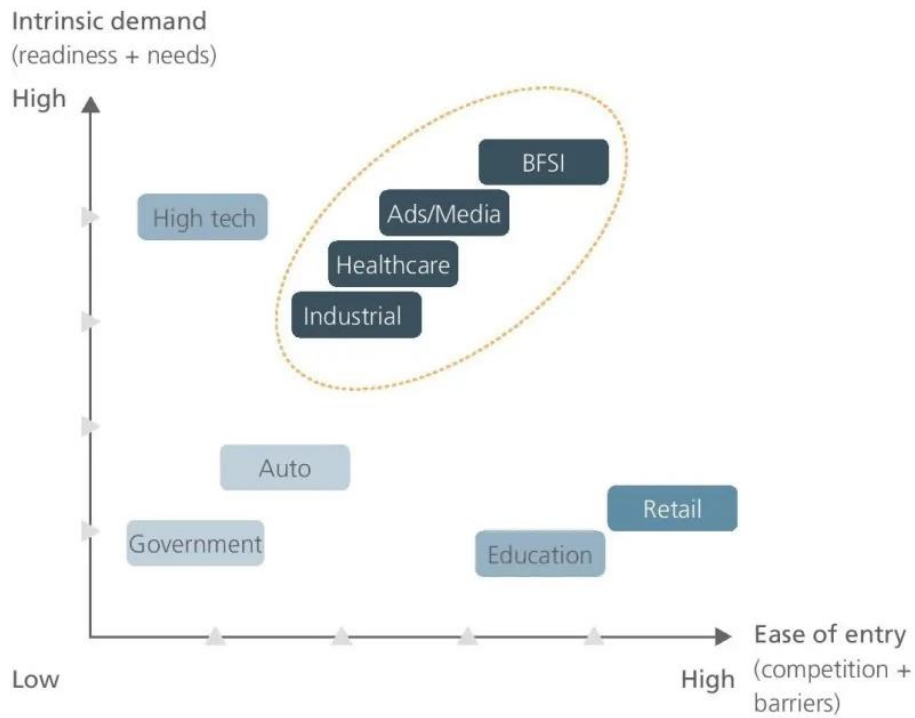
Source: Harsha Madannavar. Trillion-Dollar Market: How Can AI Companies Deliver Value? 2019

Regardless of which path and industry to try, the big players should think holistically and lay out optimal long-term gains. Three principles of the platform must be considered.

1. Easy-to-use.

   Ease-to-use and flexibility cannot be combined, and the simpler the operation, the less flexible it will be. Take AWS as an example, as shown in Figure 4.4 [24], from the top layer of

Services to the bottom layer of Infrastructure. Although the functionality is becoming more and more flexible, the use is also becoming more and more complex. Reaching a dynamic balance that best fits the user is an important goal and may be an effective path to differentiate from the competition.

Exhibit 4.4: Controllable and complex relationship of AWS AI and ML platform
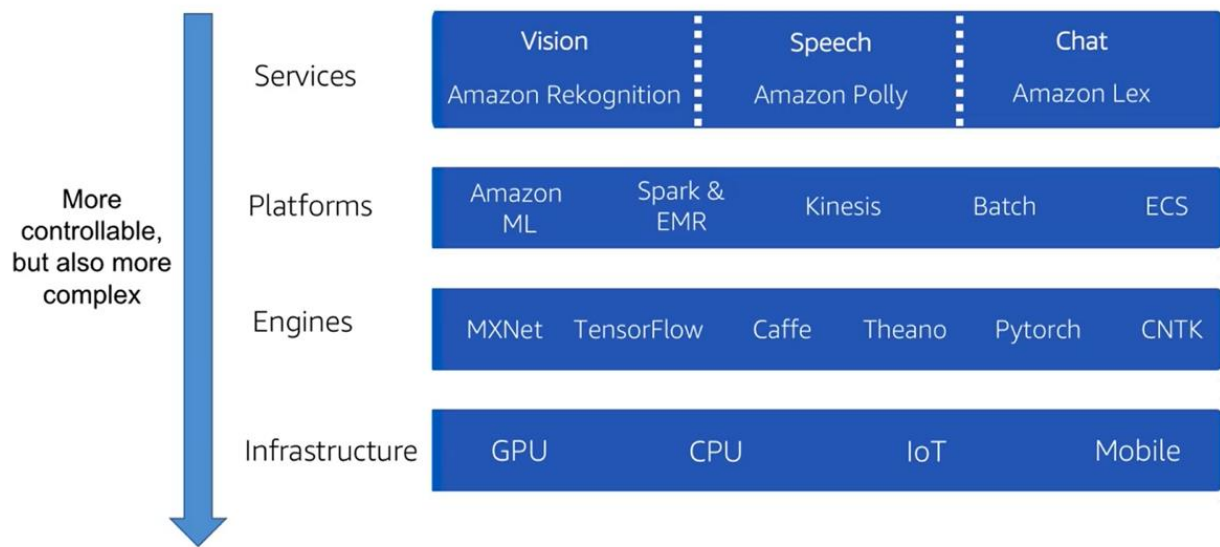
Source: Varishu Pant. Overview of all AI based Amazon Web Services (AWS), 2020

2. Completeness.

Each platform provides full-link functionality from infrastructure to platforms to services and AI and ML end-to-end capabilities from training to deployment. Users can maintain a consistent experience, smooth and efficient. And it is easier to form product dependency when users can feel completeness. However, if completeness is not met, users may seek

other platforms to achieve the desired functionality, thus allowing competitors to migrate users.

3. Openness.

As analyzed above, a platform company cannot involve all aspects of the entire AI and ML ecosystem by itself. Keeping openness, for example, using Marketplace or other ways to integrate with different frameworks and software, can make the ecosystem more competitive.

After accumulating more and more solutions of AI and ML platforms in different industries, it happens to be connected to the metaverse, which has been a big hit recently. Many people believe that it is the next generation of the internet and the future way of life for people. However, there are many different voices about the future of the metaverse, but whether it is the future or not, the R&D fever will always be there, and the process will use a lot of help from AI and ML platforms. Because whether the form of the metaverse is mixed reality or virtual reality, both the virtual and semi-virtual world requires many digital objects. And it is impossible to generate every digital object, only manual or templates.

The abilities of AI are satisfied to be more productive and efficient for generating digital objects. AIGC (AI-generated content) is a service that can provide AI abilities to generate content automatically or semiautomatically. The deep learning-based AI abilities can be separated into three categories: ASR, CV, and NLP. The related content can be voices for ASR, images, and videos

for CV, and text for NLP. Based on these capabilities, various digital objects in the metaverse world can be constructed.

Regarding the metaverse development, you can refer to the trend in Figure 4.4 [25]. From 2019 to 2030, the CAGR is expected to be 43.3%, a vast technological explosion in the next generation. Now there are significant advances in software and hardware to prepare for the high growth of the metaverse. As for the software, ASR is relatively mature for building a virtual voice. The GPT3 is a revolutionary technology for generating logical and fluent documents. The NeRF (Neural Radiance Fields) algorithm made considerable progress in CV to generate a 3D object. As for the hardware, the AR/VR equipment has also grown considerably, such as the glasses are more and more user friendly with more functions.

Exhibit 4.5: Global metaverse market 2019-2030
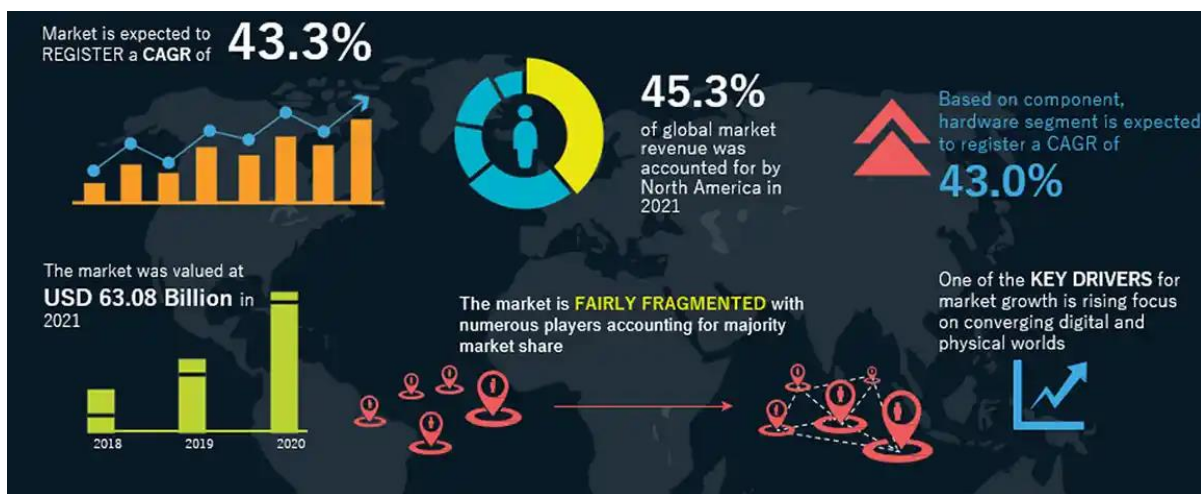
Source: EMERGEN RESEARCH, 2022

Overall, If the metaverse is the future, most of the digital world will be created with AIGC by companies or individuals. Then AIGC can be the infrastructure ability. Tech companies' AI and ML platforms are undoubtedly the breeding ground and environment for the AIGC ecosystem, which will also have enormous growth.

As for how AI and ML platforms can prepare for AIGC, for the metaverse, as mentioned above, reserve in the large-scale industry commercialization, pay attention to the three principles and focus on the existing AIGC-related applications to accelerate the rapid advancement. For example, autonomous driving companies can simulate a virtual driving environment to train independent driving algorithms. Innovative city-related companies use the digital twin for digital transformation and upgrading. The recent virtual human track is also scorching. The competition in the stock market is fierce and must be differentiated. And the incremental market must be developed with an accurate and cutting-edge vision.

Overall, because AIGC needs advanced technical support and some key technologies are still unresolved, Google, the leading AI and ML technology company may have more advantages. But Microsoft has been deep into the game field and pays much attention to the metaverse. It spent a lot of money to acquire Activision Blizzard recently. So, Microsoft may also have a critical voice. As for Amazon, as mentioned above, many SME customers give a massive boost to the AI and ML industry landing, which will help the AI capability of the metaverse.

5. Summary

This paper began by introducing the history and status of cloud-based AI and ML services within the overall development of AI and ML, and explained the basic pattern of cloud-based AI and ML platforms. AWS, Azure, and GCP rank as the top three in order, and these three occupy most of the cloud platform market share. The whole market will still grow rapidly, but the competition among the three is also very fierce.

Through the AWS, Azure, and GCP's official websites and opening API interface documents, we were able to analyze the status of cloud-based AI and ML platform capabilities and how their AI and ML platforms empowered internal applications and the external ecosystem. AWS has accumulated many small and medium-sized users due to its flywheel effect and ecosystem and it has had first-mover advantage with its cloud platform. The flywheel effect and positive closed-loop advantage is obvious. Microsoft has attracted many large companies due to its long accumulation of experience for large companies and is very competitive with its ToB matrix products. By contrast, Google's overall share of the cloud market is relatively small. Still, due to its outstanding AI and ML technology capabilities, Google's share among the AI and ML platforms is also expected to grow significantly. Each platform has distinctive features, but all provide full-stack AI and ML function from IaaS to PaaS to SaaS, and all also provide private, public, hybrid, and multi-cloud deployment methods. Competing in the same field, it is a good strategy to build on strengths and avoid weaknesses to form a differentiated competitive strategy.

Finally, we predict the development direction of cloud-based AI and ML platforms, including the future business models and outbreak trends, and analyze the corresponding platform development strategies of these three companies. For cloud-based AI and ML platforms, the infrastructure and platform functions are relatively mature at this stage, and the industry module capability for upper layer integration is still very lacking. In the future, a new business model of S2b2c may be formed, i.e., intermediate companies use the cloud-based AI and ML capabilities of platform companies to provide services to consumers according to consumer demand. This may be an advantage for Amazon, which has many small and medium-sized enterprises, but it mainly depends on which company can form the S2b2c model quickly. For the metaverse that will explode in the future, AIGC is an infrastructure technology, and each of the three companies has its own advantages. Google is a leader in AI and ML technology, Microsoft has invested heavily in the game field and in the metaverse, and Amazon has emphasized cloud-based AI and ML industry modules, promoting each capability of AI and ML in the metaverse.

In general, Amazon, Microsoft, and Google remain the leading companies with the largest market shares of cloud-based AI and ML platforms, and the competition for cloud-based AI and ML platform business will continue to be very fierce. For companies competing in the same track, it is good to combine their strengths and find a differentiated competitive strategy. For the incremental track, it is crucial to recognize and control future trends to make better strategic decisions.

Reference

[1] Rick Rieder. There's a major long-term trend in the economy that isn't getting enough attention. https://www.businessinsider.com/blackrock-topic-we-should-be-paying-attention-charts-2015-12#1-adoption-of-technology-in-the-us-1900-to-present-1, 2015. Accessed: 2022–5-5.

[2] Artificial Intelligence Platforms Market to grow by USD 17.29 bn | Evolving Opportunities with Alphabet Inc., Amazon.com Inc. & Microsoft Corp. | 17000+ Technavio Reports. https://finance.yahoo.com/news/artificial-intelligence-platforms-market-grow-230000965.html, 2022. Accessed: 2022–5-5.

[3] Hope Reese. Understanding the differences between AI, machine learning, and deep learning
. https://deeplearning.lipingyang.org/wp-content/uploads/2016/11/Understanding-the-differences-between-AI-machine-learning-and-deep-learning-TechRepublic.pdf, 2017. Accessed: 2022–5-5.

[4] Atul. AI vs Machine Learning vs Deep Learning. https://www.edureka.co/blog/ai-vs-machine-learning-vs-deep-learning,2022. Accessed: 2022–5-5.

[5] Juan Murillo Arias. What should be taken into account if Artificial Intelligence is to be regulated? https://www.finextra.com/the-long-read/62/what-should-be-taken-into-account-if-artificial-intelligence-is-to-be-regulated, 2020. Accessed: 2022–5-5.

[6] Mariya Yao. The Essential Landscape of Enterprise AI Companies (2020). https://www.topbots.com/enterprise-ai-companies-2020, 2020.
Accessed: 2022–5-5.

[7] Arutyunov, V.V. Cloud computing: Its history of development, modern state, and future considerations. Sci. Tech.Inf. Proc. 39, 173–178 (2012). https://doi.org/10.3103/S0147688212030082

[8] Laura Vietmeyer. What are the Differences Between IaaS, PaaS and SaaS? https://www.inap.com/blog/iaas-paas-saas-differences, 2020. Accessed: 2022–5-5.

[9] Alexandre. Outstanding cloud market size growth: AWS vs Azure vs GCP market share in 2021. https://holori.com/2021-cloud-market-size-and-aws-azure-gcp-market-share, 2021. Accessed: 2022–5-5.

[10] Ian Hellström. Machine Learning Platforms in 2021. https://databaseline.tech/ml-platforms-in-2021, 2021. Accessed: 2022–5-5.

[11] Technavio. Artificial Intelligence Platforms Market Size to Grow by USD 17.29 Bn| Rise in demand for AI-based solutions to boost market growth. https://www.prnewswire.com/news-releases/artificial-intelligence-platforms-market-size-to-grow-by-usd-17-29-bn-rise-in-demand-for-ai-based-solutions-to-boost-market-growth-technavio-301520153.html, 2022. Accessed: 2022–5-5.

[12] AWS Online Tech Talks. Implement AI/ML workflows with Amazon SageMaker (Hebrew). https://www.youtube.com/watch?v=TsEIFUmwFwA, 2020. Accessed: 2022–5-5.

[13] Catie Grasso. The Amazon Flywheel Explained: Learn From Bezos' Business Strategy. https://feedvisor.com/resources/amazon-trends/amazon-flywheel-explained/,2020. Accessed: 2022–5-5.

[14] 硅星人. '繁荣了 20 年的亚马逊，"中年危机"还未到来'. https://finance.sina.com.cn/tech/csj/2022-03-15/doc-imcwiwss6128319.shtml, 2022. Accessed: 2022–5-5.

[15] Dr Rabi Prasad Padhy. A Closer look at Microsoft AI Platform. https://www.linkedin.com/pulse/closer-look-microsoft-ai-platform-dr-rabi-prasad-padhy, 2019. Accessed: 2022–5-5.

[16] Develop S. Custom AI Models with Azure Machine Learning Studio and ML.NET. https://devblogs.microsoft.com/premier-developer/custom-ai-models-with-azure-machine-learning-studio-and-ml-net, 2019. Accessed: 2022–5-5.

[17] Daniel Pereira. Microsoft Business Model. https://businessmodelanalyst.com/microsoft-business-model, 2022. Accessed: 2022–5-5.

[18] PAT RESEARCH. GOOGLE AI PLATFORM. https://www.predictiveanalyticstoday.com/google-cloud-prediction-api/#rating-anchor. Accessed: 2022–5-5.

[19] Mahesh Mohan. Over 271 Google Products & Services You Probably Don't Know. https://www.matrics360.com/google-products-and-services/, 2021. Accessed: 2022–5-5.

[20] 百度百科. DeepMind. https://baike.baidu.com/item/DeepMind/19315282, 2022. Accessed: 2022–5-5.

[21] Arif Khan. Disrupt the Disruption — The Tech Oligopoly Part 2. https://blog.singularitynet.io/disrupt-the-disruption-the-tech-oligopoly-part-2-bb8747b7e16d, 2018. Accessed: 2022–5-5.

[22] 曾鸣. 《智能商业》, 中信出版集团, Page 94-104.

[23] Harsha Madannavar. Trillion-Dollar Market: How Can AI Companies Deliver Value? https://www.lek.com/insights/ei/trillion-dollar-market-how-can-ai-companies-deliver-value, 2019. Accessed: 2022–5-5.

[24] Varishu Pant. Overview of all AI based Amazon Web Services (AWS). https://medium.com/analytics-vidhya/overview-of-all-ai-based-amazon-web-services-aws-2f850eda93a8, 2020. Accessed: 2022–5-5.

[25] EMERGEN RESEARCH. Non fungible Token Market By Type (Physical Asset, Digital Asset), By Application (Collectibles, Art, Gaming, Utilities, Metaverse, Sport, Others), By End-Use, and By Region Forecast to 2030. https://medium.com/analytics-vidhya/overview-of-all-ai-based-amazon-web-services-aws-2f850eda93a8, 2022. Accessed: 2022–5-5.